



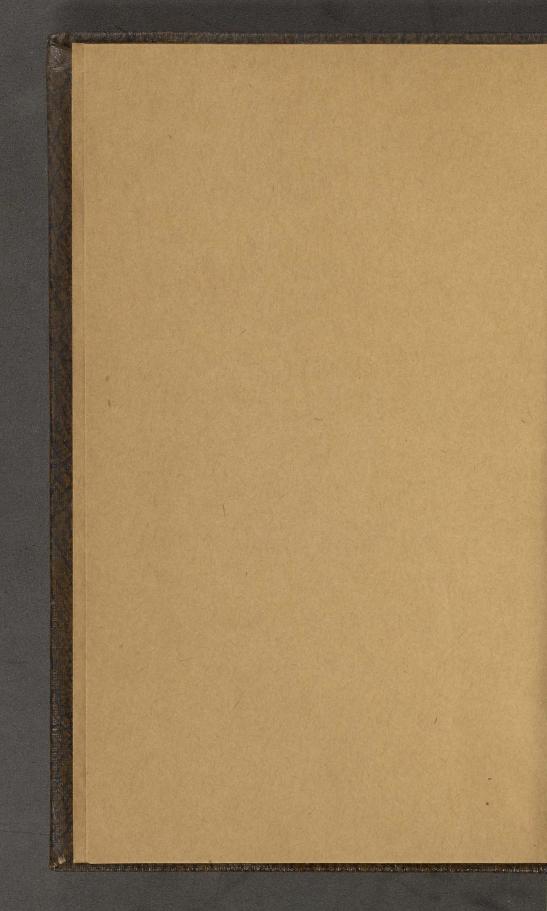
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### ANALYTICAL ESSAYS

TOWARDS PROMOTING

THE

### CHEMICAL KNOWLEDGE

OF

### MINERAL SUBSTANCES.

BY MARTIN HENRY KLAPROTH, A Berlin

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TRANSLATED FROM THE GERMAN.

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### ADVERTISEMENT.

THE merits of KLAPROTH, in Chemical Analysis, are so eminent's established with men of science throughout Europe, that it would seem improper to enlarge on the most consummate skill and accuracy with which he performed his experiments, as well as on his laudable candour in stating their results.

On this consideration, it is hoped that the translation of his Analytico-chemical Essays, &c. which is here offered to the patronage of the English Chemists, will meet with their kind approbation.—It may be necessary to add, that all the Essays of the Author relating to this subject, and which, in the German original, were published in two volumes, are, for the accommodation of the public, comprized in this single Volume.

Whenever Mr. Klaproth, as he has given hopes to the Translator, shall give another collection of his last and newest Essays, they will be immediately rendered into English.

If some typographical errors, and a few other mistakes which unfortunately have escaped the most careful attention, should create some difficulty in the sense, the reader is requested to refer to the errata in the last page.

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### PREFACE

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### THE AUTHOR.

IT has long been my defign to collect my Mineralogico-chemical Essays, dispersed in various books and journals, and to publish them, together with some new Researches; but want of time, and other impediments, have hitherto prevented me from accomplishing it.

Much as I wished to give to my Analytical Inquiries the greatest possible degree of truth and perfection, and thereby to fulfil the duties which the Chemist owes to the Science which he intends to promote by his writings, as well as to the Public, to whom he offers the fruits of his labour; I was, nevertheless, too often under the necessity of experiencing, how difficult it is to accomplish this purpose.

Of the 26 Treatifes contained in this first Vol. of Essays towards a Chemical Knowledge of Mineral Substances\*, the greater number is here published

tor

<sup>\*</sup> Mr. Klaproth here alludes to the publication of the first part of his Essays, at Berlin, 1795. The present volume comprehends also the second part of them; and what is said by the author, with respect to this last, has been added at the end of this Presace.—

for the first time. Each of them being unconnected with the others, I followed no particular order with them; and I also disregarded the order of publication, with respect to those that were before published separately. In my operations with the genus of silver-ores, I intended, for the farther advancement of the systematical part of Oryctognosy, to subject to analytical examination, not only particular species and varieties, but entire genuses, with their chief species. But I was soon convinced, that the execution of this design was impracticable, both on account of the few leisure hours which I could command, and as, in general, it surpasses the powers of an individual.

Having merely in view the progress of Natural Science, founded on pure experience, that is to say, on plain facts, free from all hypothesis, I entertain, on presenting these labours to the Public, the most ardent desire of seeing the words of Bergmann\*, "Aliorum tentamina, presertim car-"dinalia, candide sunt revidenda," put into practice; for, as this philosophical Chemist very properly adds: "Plus vident oculi, quam oculus; ideoque, quæ nova exhibentur, pluribus testibus in diversis locis utiliter consirmari puto."—Being thoroughly convinced of my own fallibility, I recommend this examination with the greater

<sup>\*</sup> De Indagando Vero.

eagerness, fince the results of several of my experiments, respecting the constituent parts of fossils, are, frequently, in striking contradiction to those given by others. Thus the mineralogical world may be informed, on which fide truth stands, or the least error occurs; and the Oryctologist may, with greater certainty than before could be done, apply the data given him to the perfection of his art. On my part, I shall always receive with pleafure any well grounded correction of my labours, and better information.

With respect to those, who may possess patience and inclination sufficient to undertake a repetition of my experiments, I have described every particular management, as circumftantially as could be done, confistently with keeping within due bounds that prolixity which is hardly ever feparable from the narrative of chemical processes. Those who are familiar with this subject, will perceive my endeavours to reduce the analysis of mineral bodies to methods which are fimple in themselves, and lead to results that may be depended on. Among others, I flatter myfelf with having traced out a way of analyfing gems, which feems to deferve being followed by skilful Chemists.

A circumstance, seemingly indifferent, often produces in chemical experiments, as in other inveftigations, unexpected confequences; which may be

proved by comparing my former with my later analytical experiments, made with the Adamantine Spar, and Circon (Jargon of Ceylon), which, on this account, I have placed next to each other in the respective Treatises. Who, for example, would have imagined, that the application of caustic alkali in the liquid state should so exceedingly facilitate the opening of hard stony matter, and remove the greatest part of the difficulties with which I had to struggle, when employing the same separating medium in the dry state?

As many perfons think that the preparation of a perfectly pure caustic lye is subject to more difficulties than it really is, I will here briefly ftate my method of preparing it. - I boil equal parts of purified falt of tartar, (carbonat of potash, or vegetable alkali prepared from tartar) and Carrara marble, burnt to lime, with a fufficient quantity of water, in a polished iron kettle; Istrain the lye through clean linen, and, though yet turbid, reduce it by boiling, till it contain about one half of its weight of cauftic alkali; after which I pass it once more through a linen-cloth, and fet it by in a glass bottle. After some days, when the lye has become clear of itself, by standing, I carefully pour it off from the fediment into another bottle. To convince myself of its purity, I faturate part of it with muriatic or nitric acid, evaporate it to drynefs, and re-diffolve it in water. If it be pure, no turbidness will take place in the folution. The quantity of caustic alkali, which this lye contains, I ascertain by evaporating a certain weighed portion of the lye to dryness, in an evaporating dish of a known weight. I also take care, in the preparation of this caustic lye, that the alkali be not entirely deprived of carbonic acid; because, in that case, I can, with greater certainty, depend on the total absence of dissolved calcareous earth. By employing burnt marble, or, in its stead, burnt of the caustic lye by aluminous earth; because lime, prepared from the common species of lime-stone, is seldom entirely free from argil.

Befides, the choice of the veffels requires great care. Since even the best porcelain is attacked and disfolved by caustic alkali, I employ silver, reduced from muriat of silver, (Horn-silver), for vessels appropriated to sussion. This material, however, notwithstanding its other advantages, is not absolutely free from all inconvenience. For, if the crucible made of its has not been prepared with every possible care, small scales will detach from it, which mingle with the body to be examined, and frequently occasion illustive appearances. Having already found, unexpectedly, that even a crucible made of platina would not, as had been wished, resist the action of ignited caustic alkali; I imagine that a crucible made of pure massive gold would

be the most eligible. On this account, Professor Storr seems to be in the right, when he concludes his Proposals, respecting the examination of the mixture of gems\*, with the following words: "The difficulties occurring in this operation will the sooner disappear, if a great amateur of gems should choose to spend the value of some thousand ducats for their examination." Meanwhile, I flatter myself with having in some manner counteracted those difficulties; though I was not encouraged by such a high premium.

Though for the most part I have followed the new nomenclature, I have not scrupulously confined myself to its terms; but have, for the sake of brevity, now and then used the denominations, Glauber's-salt, Common-salt, Horn-silver, Bloodlye, &c. as also the term mild, in stead of carbonated, in opposition to caustic†. Speaking of water, to avoid too frequent repetitions, I have mostly omitted to particularize it as distilled. Thus, also, I have not in every single instance mentioned the edulcoration of the precipitates, or residues; this and similar operations being always understood to have been performed.

\* Crell's Chemisches Journal, vol. VI. 1781.page 227.

<sup>†</sup> The Translator, however, has, for the most part, preferred the new nomenclature, and frequently added the former denominations, for reasons not necessary to be particularly mentioned.—Transl.

### Concerning the Second Part.\*

I HERE offer to the chemical and mineralogical public the fecond volume of my Essays, &c. animated by the hope, that it will meet the same encouraging approbation with which the first has been honoured by scientific men, whose decision in this branch of the Knowledge of Nature commands respect.

The numbers of the Essays, contained in this volume, proceed in a continued series with those of the preceding. Of those now given (1797), only a few have been before printed in various publications, and are here merely collected.—All the others are entirely new, and, at present, published for the first time.

As these essays were the fruit of my leifure hours only, several of them have not arrived at that degree of perfection, to which, perhaps, they might

<sup>\*</sup> This is the Preface to Mr. Klaproth's fecond volume of the German Edition; and the words, Part 1. and Part 11. have been designedly inserted in the following Table of Contents; the better to distinguish the first 26 Essays belonging to the first volume from the remaining essays, published in the second volume of the original.

have approached, if the usual avocations of my duties had permitted me to perform them with greater convenience and opportunity.

In this respect I earnestly wish, that, for the advancement of the science, the chemico-analytical researches published in this second volume may share the same good fortune with those of the first:

—I mean to say, that they may be examined, corrected, and farther pursued by expert Chemists.

M. H. KLAPROTH.

### [ xiii ]

### CONTENTS,

### PART I.

		Page
I.	EXPERIMENTS concerning the Habitudes of various Species of Stones and Earths in the Heat of a Porcelain-furnace.	I
YT.	Analysis of the black-grey Flint	39
	Experiments on the Adamantine Spar	
	First Section	43
	Second Section	59.
	A. Adamantine Spar, from China	64
IV.	Examination of the Oriental Sapphire	71
	Examination of the Cat's-eye	78
7 7	A. From Ceylon  B. — the Coaft of Malabar	79
	B. — the Coast of Malabar	182
VI.	Analysis of Chrysoberyl	85
VII.	Examination of Chrysolite . ,	91
VIII.	Examination of Olivin	99
	First Section. Olivin, from Unckel	100
	Second SectionKarlsberg	105
IX.	Examination of various Silver-ores  First Section. Native Hornsilver	109
	A. Masteve, from Saxony	115
	B. Corneous Silver-ore, from Schlangenberg.	119
	C. Argillo-muriated Silver-ore	ib.
	D. Of Justi's supposed alkaline Silver-ore	121
	A. From Andreasberg, in the Upper Harz	127
	B Freiberg, in Saxony	134
	Third Section. Vitreous Silver-ore	137
	A. From Freiherg  B. —— Joachimsthal, in Bohemia	138
	Fourth Section. Brittle vitreous Silver-ore	140
18 .	Fifth Section. White Silver-ore	143
	A. Light-ditto, from Erbifdorf, near Freiberg .	145
	B. Dark-ditto, from Freiberg	149
	Seventh Section. Native Amalgam of Silver	156
	Eighth Section. Arsenical Silver, from Andreasberg.	
X.	Examination of the Oriental Lapis Lazuli	1
		XI.

### CONTENTS.

		* 1
		Page
XI.	Examination of the Smalt-blue Fossil, from Vorau, in Austria	170
XII	Examination of the Jargon of Ceylon (Circon)	
4211.		175
	First Section	188
XIII.	Examination of Hyacinth	195
XIV.	Examination of the fupposed Hungarian Red Shörl	200
	Examination of a new Fossil, from Passau	211
XVI.	Examination of the fupposed Molybdenous Silver .	218
	Examination of the Native Alumine, from Schemnitz	22I
XVIII.	Chemical Refearches into Strontianite compared	
	with Witherite	223
	Examination of Lepidolite	238
	Examination of Cimolite	, 248
XXI.	Examination of the Magnefian Spar	256
7	A. From Tyrol	259
XXII.	Examination of the Supposed Muriacite	262
XXIII.	Examination of the Native Alum, from Miseno .	266
XXIV.	Examination of the Native Nitre, from Molfetta.	270
XXV.	Examination of the Mineral Springs at Carlsbad,	
	in Bohemia	274
XXVI.	Examination of the Saline Springs at Königsborn, and their Products	298
	and men froducts	290
	PART II.	1-2
	EXAMINATION of Spinell	316
XXVIII.	Examination of the Emerald, from Peru	325
	Examination of the Bohemian Garnet	329
	Examination of the Oriental Garnet	334
XXXI.	Examination of Vefuvian	0
	First Section. Vesuvian, from Vesuvius Second Section. ————————————————————————————————————	338
VVVII	Examination of Leucite	3,
AAAII.	First Section. Leucite, from Vesuvius	348
Un Var	Second Section. The fame continued	352
1	Fourth Section in irregular masses	361 363
	Fourth Section. ————————————————————————————————————	
	I. From Pompeji	364
	2. — Ronciglione	365 XIV.
	AA	LAL V a

	Page
XXXIII. Examination of Pumice-stone, from Lipari .	. 368
XXXIV. Examination of the Terra Australis (Sidneia) .	371
XXXV. Examination of the granular Sulphat of Barytes, from Peggau	375
XXXVI. Examination of the testaceous Sulphat of Ba-	313
rytes, from Freiberg	378
XXXVII. Examination of Staurolite (Cross-stone)	384
XXXVIII. Farther Refearches into Witherite and Stron- tianite	
First Section	387
XXXIX. Examination of the Sulphat of Strontian, from	390
Pensylvania	394
XL. Examination of the Water of the Boiling Spring.	
at Rykum, in Iceland	399
XLI. Examination of the filiceous Tusa (Kiefeltuff) from the Geyser, in Iceland	406
XLII. Examination of the Elastic Quarz, from Brafil.	409
XLIII. Examination of the Hvalite (Glass-stone), from	
Dauphiny	413
XLIV. Examination of Chrysoprase, and its concomitant green Earth	
First Section. Analysis of Chrysoprase	420
Second Section. Analysis of the green Earth of Chrysoprase	1
XLV. Examination of the Noble Opal, from Cfcherwe-	425
nitza, in Upper Hungary	440
XLVI. Examination of the Hydrophanes, from Saxony .	443
XLVII. Examination of the White and Green Opal,	
from Kosemütz, in Silesia	445
banya, in Upper-Hungary	447
XLIX, Examination of the Brown-red Semi-opal, from	
Telkebanya, in Hungary	449
L. Examination of Menilite, from Menil-montant,	451
LI. Examination of Werner's Polishing-Agte, from	,
Menil-montant, near Paris  LII. Examination of Silici-murite (Meerschaum), from	455
the Levant	n 456
the Levant	75
from Bareuth, in Franconia	460
LIV. Examination of Steatites (Soap-rock), from Cornwall	462
LV. Examination of the Chinese Agalmatolite (Plastic-	100
ftone)	465
	LVI

		Page
LVI.	Second Examination of Lepidolite (page 238)	
LVH.	Examination of Uranite	476
	Examination of two newly discovered Titanites,	
	from Spain, and Aschaffenburg, in Germany	496
LIX.	Examination of fome ferruginous Titanites, from	
	Cornwall	499
LX.	Examination of the Garnet-shaped Ore of Manga-	
1	nese, from the Spessart	510
LXI.	Examination of the Native Oxyd of Tin (Tin-stone)	515
LXII.	Examination of the Native Sulphuret of Tin (Tin-	
	pyrites), from Cornswall	525
LXIII.	Examination of the Molybdat of Lead, from Blei-	
the way	berg, in Carinthia	532
LXIV.	Examination of the Sulphuret of Copper (vitreous	4
	Copper-ore, Kupfer-glanz), from Siberia	541
LXV.	Examination of the variegated Copper-ores (Bunt-	
1 1	kupfererz) from Hitterduhl, in Norway, and Ru- delfladt, in Silefia	545
TXVI	Examination of the Siberian Malachites	550
	Examination of the Bifmuthic Silver-ore, from	330
TWAII.	Schapbach, in Suapia	554
XVIII	Examination of the Antimoniated Silver, from	224
J21 V 111.	Wolfach, in Suabia	560
LXIX.	Examination of the erystallized, bright, white, Co-	
	balt-ore (Glanz-kobalt), from Tunaberg, in Sweden	564
LXX.	Examination of the Cobaltic Ore of Manganese,	
	from Rengersdorf, in Lusatia	569
LXXI.	Examination of the Native Sulphat of Cobalt (Ko-	
	balt-vitriol) from Herrengrund, in Hungary	579
LXXII.	Examination of the Mineral Springs at Imnau, in	-
	Suabia	580

### EXPERIMENTS

ON THE

### HABITUDES OF VARIOUS SPECIES

OF

#### STONES AND EARTHS

IN THE

#### FIRE OF A PORCELAIN-FURNACE.

A SCIENTIFIC enquiry into that class of natural bodies, which belong to the mineral kingdom, includes a number of particulars, which it is necessary to unite, in order to obtain a complete knowledge of the subject.

#### These are:

- I. Their geognofic fituation \*: and
- 2. Their external characteristic marks: which both together constitute their natural history.
- 3. The experiments relating to the physical properties and powers of bodies in an undecomposed state. Such are: their specific gravity, elasticity, magnetic attraction, the phenomena exhibited by them with regard to light, and the like.
- 4. Their habitudes or changes in the fire; and
- 5. Their chemical constituent parts.

<sup>\*</sup> Werner, who introduced the expression Geognoss, understands by it a general acquaintance with the solid parts of our globe, the various situations or beds of sossils, and their reciprocal relations to each other. Thus he distinguishes geognoss from mineralogical geography, which only treats of the native places of sossils.—Transl.

As to the habitudes of minerals in fire, they indeed belong to the chemical part of natural science; but so far only, as their constituent parts, or their proportions to each other, are made to suffer an alteration by this agent. Therefore, the phenomena, which take place on warming or heating, without producing a lasting change in the chemical mixture of the constituent parts, do not belong to this, but to its physical part. Thus, for instance, the power of attracting and repelling light bodies, excited in Tourmaline by warming it, should only be reckoned among its physical properties; but, on the contrary, the phosphorescence of the Fluor-spar and the Apatite, though but moderately heated, already effect some alteration in the natural chemical proportion of their constituent parts.

Though feveral industrious naturalists have examined various species of earths and stones merely by fire, sew of them, however, have surnished simple facts or experiments. Some, as Pott and Gellert, according to their particular purposes, have directed their attention more to the products of sussing, in compositions of their own making, than to the mere habitudes of the simple soffils. Others, D'Arcet for instance, have indeed had regard to this last circumstance; but they have missed their end, at least for the greatest part, by exposing the body under trial to fire in immediate contact with argillaceous crucibles. For, the results could not fail to be false in most cases, on account of the aluminous earth from the corroded mass of the crucible mingling with the substance of the experiment.

So far as I know, Mr. Gerhard\* is the only chemist, who, in his valuable experiments concerning the habi-

<sup>\*</sup> Gerhard's Versuch einer Geschichte des Mineralreichs, 2 Vol. Berlin, 1781-82.—Vol. II. § 2. page 8-44.

tudes of fossils in the fire, has paid due attention to the nature of the vessels; and has communicated true results, because in his operations he employed crucibles of charcoal, besides those manufactured of clay and chalk.

The results of my experiments on the effects produced by fire on various species of stones and earths, which I am now about to give, may serve to confirm several, and in some respects be considered as a continuation of those of Gerhard.

When speaking of the experiments on sussion made by the above mentioned naturalists, as well as of my own, the mere action of common fire in wind and porcelain-furnaces is understood. Hence, neither dioptrical and catoptrical experiments belong to this investigation; nor those, which several philosophers have made by strengthening the fire by means of oxygen gas. For, howsoever valuable the latter are in other respects, I am inclined to think, that in a mineralogical view, the action of violent ignition sustained by oxygen gas is not a convenient method for ascertaining the relative habitudes of minerals in the fire.

To be enabled to draw just conclusions from experiments of this kind, it is necessary that they be all performed with the most equal degree of heat. This advantage was assorded to me by the furnaces of the Royal Porcelain-manufactory (at Berlin); into which the fossils, ready prepared for this trial, were put; together with the porcelain, subjected to final baking.

For experiments to be performed in charcoal crucibles, a cavity was made in a thick fragment of well-burned charcoal, of a volume answering the size of the fossil. This being put in, the cavity was closed with a charcoal stopper;

after

4

after which the charcoal-crucible was fitted into another crucible made of baked clay, and this last well joined with its cover by luting.

In order to make comparative experiments, I placed another quantity of each fossil immediately in a crucible made of clay unmixed with iron. After the cover had been luted on, it was exposed to the same intensity of heat.

In every case where the loss of weight could be ascertained with some degree of certainty, I have always mentioned it.

### No. I. ADULARIA; from Mount St. Gotthard.

- a) In the charcoal-crucible\*, a colourless glass, clear in its substance, but quite sull of very small froth-bubbles. On this account it appears of a greyish-white, and exhibits no vitreous splintery fracture, but a minute conchoidal, with very sine pores.
  - b) In the clay-crucible. The fame.

### No. 2. White ALABASTER.

a) CH. Cr. was rendered moderately hard, white passing into straw-yellow, in some places finely streaked, of a fine-grained earthy fracture, adhering to the tongue, and emitting an odour like that of alkaline sulphuret.—Loss of weight, 0,56.

In the same manner L. of W. means loss of weight.

<sup>\*</sup> For the fake of brevity, the Charcoal-crucible is marked CH. Cr. and the Clay-crucible, CL. Cr.

b) CL. Cr. A black-brown glass, very shining, little transparent on the edges, with separate bubbles.

### No. 3. AMIANTHUS; from Greenland.

- a) CH. Cr. A roundish fused scoria, of a dirty pearl grey, externally covered with some small grains of iron. Fracture, dull, finely porous, with dispersed inlaid glossy particles.
- b) CL. Cr. Has run into a greenish, opake scoria, of a fracture almost dull. The whole surface covered with crystals of a greenish and light brown colour, in the form of delicate needles, of a reticular form.

## No. 4. ASBESTUS, mountain green: (Berg-holz) from Siberia.

- a) CH. Cr. Unaltered as to form, simply hardened by ignition. Its surface invested with a thin reddish crust; the edges blackish, and overlaid with fine exsuded grains of iron.—L. of W. 0,16.
- b) CL. Cr. The form likewise unchanged; of a lightbrown colour, rendered very hard, and covered with some ferruginous spots.

### No. 5. ASBESTUS; from Taberg.

- a) CH. Cr. A light-grey flag, fused into a sphere, and covered with grains of iron, of a glittering surface, and having detached, shining, large bubble-holes—L. of W. 0,25.
- N. 6. BASALT; ash-grey, coarse-grained. (Swed. Trap; and, according to Werner, Grünstein;) from Hunneberg, in Westgothland.
- a) CH. Cr. Fused into a compact glass, of a clovebrown colour, transparent in splinters, of a large con-B 3 choidal

choidal fracture. Externally, partly glazed brown, partly invested with a ferruginous crust, and large grains of iron.

—L. of W. 0,06.

- b) A folid black glass, covered with a brown, steel-grey, veined iron-crust.
- No. 7. BASALT, dense, columnar; from the Hasenberge, in the middle mountains of Bohemia.
- a) CH. Cr. Externally, a compact grey mass, richly over-laid with pretty large grains of iron, and in part also covered with a tombac-brown ferruginous crust. Its fracture of a bright ash-grey, and to appearance dull and earthy; but if examined with a lens, possessed of a texture very finely porous, and spongy throughout; and very rough to the feel.—L. of W. 0,09.
- b) CL. Cr. A black dense glass, transparent, and of a clove-brown, in thin splinters, of an even or gross-conchoidal fracture. At the top, it exhibits a light-brown, glossy, and delicately-slowered crust.
- No. 8. BASALT, dense, columnar; from Stolpe, in Saxony.
- a) CH. Cr. A compact mass, invested at the top with a blackish grey glazing, but, on the sides and underneath, with numerous grains of iron, and in part covered with a tombac-brown iron-crust. In fracture, ash-grey, dull, dense, somewhat splintery, in some places of a spongy texture hardly distinguishable, and in others exhibiting clove-brown glossy veins.—L. of W. 0,08.
  - Note 1. Another, but smaller quantity of the same basalt, treated in the same manner, I found, had the same external appearances: but its internal colour was white-grey; its texture was more dense, and traversed by minute, blackish vitreous veins.

Note

- Note 2. I put the specimen of No. 8. a) a second time into the charcoal crucible, after having separated the iron-grains. It appeared afterwards of an amorphous, and on the upper part confusedly sibrous form; but its fracture presented a darkish grey, compact, fine-grained, untransparent, highly glittering, and, towards the sides, greasy glossy scoria.
- b) CL. Cr. As No. 7. b).
- No. 9. BASALT, largely perforated, with interspersed, fingle, small grains of olivin; from the island of Skye.
- a) CH. Cr. On the furface overlaid with many grains of iron, of a confiderable fize. Fracture dark ash-grey, very rugged, dull, and earthy; but, viewed by a lens, spongy, with fine pores.—L. of W. 0,08.
  - Note. The grains of iron being separated, this mass was again placed in a fresh CH. Cr. Its surface then assumed the figure of vermicularly twisted branches, lying stat; some of which had a copper-red metallic lustre. Its fracture like No. 8, note 2.
  - b) CL. Cr. The fame as No. 7. b)
- No. 10. BASALT, porphyraceous; from the new Cammeni, near Santorini.
  - Note. The principal black mass was a medium between filiceous shiftus, (Kiefelschieser) jasper, and basalt; with diffeminated tender, white, vitreous squares and grains.
- a) CH. Cr. Melted into a folid, blackifh glass; whose fragments were of a yellowish-green, and transparent. It was covered with a steel-grey ferruginous crust, and of a glossy, large conchoidal fracture.—L. of W. 0,02.
- b) CL. Cr. A compact, black glass; but its splinters clove-brown and transparent. Fracture of the large, and, in some degree, smooth conchoidal form. Surface invested with a bright brown, shining pellicle.

## No. 11. LIGNIFORM ASBESTUS (Bergholz), brown; from Tyrol.

- a) CH. Cr. Suffered no alteration of form; burned hard, and affumed a greenish-brown surface, with a red and white investment. Its edges soliated in lamellæ, blackish, and garnished with extremely delicate exsuded grains of iron. Fracture bright, steel-grey, and glittering.—L. of W. 0,39.
- b) CL. Cr. Coalescing by sustion with the parts of the crucibles that were in contact with the fragments. Their external surfaces exhibited a texture, consisting of brown, resplendent, implicated, short striæ. The fracture darkgrey, little shining, and of bright-grey rays and points, as it were interwoven, with some air-bubbles.

### No. 12. BERYL, yellow; from Siberia.

- a) CH. Cr. No change in the figure. Colour dirty pale-bluish-grey, with a greafy lustre, and a little transparent. Fracture uneven, gross-splintery.—L. of W. 0,01.
  - b) CL. Cr. The fame.

### No. 13. BERYL, fea-green; also from Siberia.

- a) CH. Cr. In general of less splendour; but the lateral surfaces of the column covered all over with fine, shining, needle-formed radii. In other respects, as No. 12. a)
  - b) CL. Cr. Like No. 12. b)

# No. 14. SHORLITE (Schörlartiger Beryl); from Altenberg.

- a) CH. Cr. Unaltered as to form; indurated by the ignition; became grey, dull, and rough; with minute glittering points of a nearly metallic luftre.—L. of W. 0,25.
- b) CL. Cr. The fame phenomena; but without shining points.

No.

### No. 15. PUMICE-STONE, common; from Lipari.

- a) CH. Cr. A bluish-black-grey, dense glass, with some air-bubbles; semi-translucid when reduced to thin fragments; and externally overlaid with a few grains of iron. L. of W. 0,10.
- b) CL. Cr. Afforded a clearly fufed, light-blackift-green, glaffy fubftance, of almost colourless and clear splinters, with some air-bubbles.

## No. 16. COMPOUND SPAR (Bitterspath); from Zillerthal, in Tyrol.

- a) CH. Cr. Fell into finall yellowish-grey, and yellowish-brown, friable, and in part distinctly rhomboidal pieces, of an earthy appearance.—L. of W. 0,45.
- b) CL. Cr. On the upper part it run into a clear, bright grass-green glass, of a smooth surface; but on the lower part into a light-grey frothy scoria.

### No. 17. BOLE, red armenian; genuine.

Note. Consists of a red, friable lithomarga (Steinmark), with white speckles.

- a) CH. Cr. Burned hard, was glittering, and of an iron-black colour.—L. of W. 0,20.
- b) CL. Cr. Hardened by burning; partly fleel-grey, partly dirty-brown; having the furface covered with transuded and re-calcined or oxyded ferruginous particles; rough and porous.

### No. 18. BOLE, red armenian; common.

a) Melted into an ill-shaped hollow globe, whose outward and inward surfaces were of a dim steel-grey colour, and and inlaid with resplendent grains of iron. Its fracture presented a black-grey slag, shining, and in part porous.— L. of W. 0,16.

b) CL. Cr. Gave a brown scoria; glossy like pitch; full of large bubbles; of an uneven surface, resembling the specular or grey iron-ore (eisen-glänziz).

### No. 19. BORACITE; from Lüneburg.

- a) CH. Cr. Each crystal fell separately into a globular form; acquired a cavity in the middle, and presented here and there incumbent, very tender ferruginous grains. Fracture whitish-grey, shining, uneven, and soliated; in part also striated.
- b) CL. Cr. Produced a yellowish, clear glass, containing some air-bubbles; and having separate, small, dimwhite spots.

# No. 20. SIDERO-CALCITE (Braunspath), in lumps\*, grey-white; from Freyberg.

a) CH. Cr. Fell into black-brown, cracked and friable lumps, entirely refembling perfectly decayed fiderocalcite, and shewed exceedingly minute, transuded metallic grains.

<sup>\*</sup> In German derbe, the precise meaning of which expression Kirwan asserts, (Elem. of Mineral. I. p 26) he could never learn. According to Emmerling, any solid fossil is called derbe which is concreted or imbedded in another, and is of the fize of a hazelnut, and above, to any magnitude; whereas that which is called in German cingesprengt (disseminated, interspersed) is under the fize of a hazelnut, to any minuteness observable. As the fize of the sossil treated of in this work is seldom determined, the word derbe will be given in this translation by the expressions in lumps, in masser, and sometimes masser.—Transl.

b) CL. Cr. Changed into a glass of a dark black-brown colour, transparent on the edges, and pellucid in small fragments.

#### No. 21. CORNELIAN, criental.

- a) CH. Cr. No change in its form, very fragile, of a fnowy-white from the outer edge, almost to the thickness of  $\frac{1}{12}$  inch; but internally very pale reddish white. The fracture of the white border was conchoidal and resplendent; that of the inner parts earthy and dull.—It suffered no loss of weight.
- b) CL. Cr. Throughout of a snow-white, partly spotted, somewhat greyish, and preserving its external splendour.

### No. 22. CHALCEDONY; from Ferröe.

- a) CH. Cr. Of unaltered shape; white as snow; easy to be broken; externally, and in the fracture, glittering.—L. of W. 0,01.
  - b) CL. Cr. The fame.
- No. 23. CHLORITE, loose, from the cavity of a rock-crystal; from St. Gotthard.
- a) CH. Cr. A contracted, black, shining, somewhat radiated mass, similar to a brittle pit-coal.
- b) CL. Cr. Fused into a solid, black-brown, vitreous substance.

### No. 24. CHRYSOBERYL, from Brafil.

- a) CH. Cr. Remained totally unchanged, except that its furface became a little rougher.
- b) CL. Cr. Likewise unaltered; only its colour turned somewhat paler, and the external surface acquired spots of a dull white.

No.

#### No. 25. CHRYSOLITE, oriental.

- a) CH. Cr. Its furface covered with a thick ferruginous crust, of a reddish-brown, passing into steel-grey, and glittering. Its original green colour was no longer perceivable in the fracture. Its form, splendour, and transparency, quite unaltered.
- b) CL. Cr. No change as to form, transparency, and lustre; but the colour inclined now to olive-green.

### No. 26. CHRYSOPRASE; from Kosemütz.

- a) CH. Cr. Had its figure unaltered, turned very light blackish-grey, of a strong gloss, and perfectly opake. In the streak it exhibited a kind of metallic lustre.—L. of W. 0,01.
  - b) CL. Cr. The same effect.

No. 27. CIMOLITE; from the island of Cimolo (Cimolia Plinii).

- a) CH. Cr. A black-grey, moderately shining, scummy slag, of little weight.—L. of W. 0,25.
- b) CL. Cr. A yellowish-white, half fused, hard, small frothy scoria, resembling corroded quarz.

No. 28. CYANITE, crystallized; from St. Gotthard.

- a) CH. Cr. Burned white, was split, became very friable, and internally shining.—No loss of weight.
  - b) CL. Cr. The fame.

No. 29. CYANITE, common; from the same place.

- a) CH. Cr. Was rendered ash-grey by ignition, and split, in the manner of wood.—No loss of weight.
  - b) CL. Cr. Snowy-white, and split.

No.

No. 30. FEL-SPAR? compact, blue; from Krieglach.

a) CH. Cr. Furnished a grey-white glass, scummy in the fracture, and thereby divided into shapeless cellules, like fine tabular quarz. It presented detached ferruginous grains, and shewed also on the surface a number of fine splendid speckles .- L. of W. 0,40.

b) CL. Cr. Shrunk into milky-white, irregular, rough lumps, with a distinctly beginning vitrification.

No. 31. FEL-SPAR, common, red; from Lomnitz.

- a) CH. Cr. As No. 1. a)
- b) CL. Cr. As No. 1. a) The month and the same

No. 32. FEL-SPAR, vitreous, in hexagonal plates; from the Porphyry of Drachenfels.

a) CH. Cr. A greyish-white glass, almost pellucid; of a strong gloss on the fracture, and having air-bubbles. -L. of W. 0,02.

b) CL. Cr. A femi-pellucid, bright-grey, fomewhat frothed glass; in some places speckled blackish or brownish.

No. 33. FEL-SPAR, green; from Siberia.

- a) CH. Cr. Like No. 32. a)
- b) CL. Cr. Produced a milk-white glass, of a fine froth, but clear in small pieces.

No. 34. FLUOR-SPAR, yellow, cubic; from Gersdorf.

- a) CH. Cr. A milky-white fcoria; fused on the outfide; in the fracture lamellar, of resplendent planes.-L. of W. 0,04.
  - b) CL. Cr. Fused into a clear, bright grass-green glass.

# No. 35. SPECULAR GYPSUM (Fraueneis, glacies Mariæ.)

- a) CH. Cr. Rendered white, very friable; and its lamellæ specular or reslecting light.—L. of W. 0,60.
- b) CL. Cr. Clove-brown glass, with large spherical air-bubbles.

## No. 36. HYALITE, or Glass-stone, (VIOLET SHOERL); crystallized; from Dauphiny.

- a) CH. Cr. A femi-pellucid greyish-white glass, brilliant, flat conchoidal fracture; outwardly spread over with ferruginous grains.—L. of W. 0,12.
  - b) CL. Cr. A dense, semi-pellucid, deep clove-brown.

### No. 37. HYALITE (Violet Shörl), in masses; from Thum (Thumerstone).

- a) CH. Cr. As No. 36. a).-L. of W. 0,10.
- b) CL. Cr. As No. 36. b).

No. 38. MICA, grey, gross-foliated; from Cornwall.

- a) CH. Cr. A greenish-grey, semi-pellucid glass, overlaid with minute grains of iron.—L. of W. 0,10.
- b) CL. Cr. Run into a compact, blackish, opake glass; of a smooth, strongly-shining surface, and conchoidal fracture.

### No. 39. GARNET, red, bohemian.

- a) CH. Cr. Afforded a grey, turbid glass; full of grains of iron.
- b) CL. Cr. Fused into an opake, almost compact scoria, whose colour internally changed by stripes from brown into green; very finely corroded.

No

#### No. 40. GARNET, oriental.

- a) CH. Cr. The fame change as No. 39: a).
- b) CL. Cr. Yielded a compact black glass; of a bright lustre; covered with a steel-grey crust.

## No. 41. GRANATITE, (till now fo called); from St. Gotthard.

- a) CH. Cr. Became hard; fleel-grey; overlaid with small ferruginous grains.
- b) CL. Cr. Rendered hard; of an iron black colour; with shining points of a metallic lustre.

#### No. 42, GREEN EARTH; from Cyprus.

- a) CH. Cr. Fused into an irregular sphere; which had externally a dirty green colour, and presented in the fracture a somewhat porous mass, composed of an emerald-green glass and a pale-green scoria. Here and there it was crossed partly by white metallic lamellæ, partly by reguline copper. There was also found, in one of its cavities, a variegated copper-ore in small grains.—L. of W. 0,17.
- b) CL. Cr. Exhibited a fused compact scoria; in the fracture of which the upper part was brown and resplendent; the lower one greenish grey, and glittering. At top it shewed grey-white, delicate plumose traces, of a lustre mearly metallic, upon a brown ground.

#### No. 43. HELIOTROPIUM, oriental.

a) The figure unaltered; but rendered a little fofter by the ignition. The colour changed from dull-greenish to a grey-white. Its fracture uneven, splintery, rough and glittering. The red points, which had disappeared, left small holes behind them.—L. of W. 0,01.

- b) CL. Cr. The colour turned throughout whitish grey. In other respects as at a).
- No. 44. HORN-BLENDE, basaltic; from the crater of Vesuvius.
- a) CH. Cr. A hardened, ill-shaped mass, with grains of iron. Fracture light-grey, uneven, faintly glittering; without any trace of vitrification.—L. of W. 0,10.
- b) CL. Cr. Melted into a dense, black-brown glass; transparent in thin fragments; of a smooth surface, and a slat conchoidal, glossy fracture.
- No. 45. HORN BLENDE, common; from Neurode, in the county of Glatz, in Bohemia.
- a) CH. Cr. An indurated mass; on the outside wrinkled, of a colour verging into copper-red, inlaid with many granular particles of iron. Internally light pearly-grey, uneven, slightly glittering; here and there with a beginning vitrification.—L. of W. 0,06.
  - b) CL. Cr. As No. 44. b).
- No. 46. HORNBLENDE? common; from Nora, in Westmanland.
- a) CH. Cr. Run into an imperfect, greenish-black vitreous substance, transparent on the edges, overlaid with an iron black, rugose or shrivelled crust. Fracture, with airbubbles, of a copper-colour.—L. of W. 0,14.
- b) CL. Cr. A compact scoria, whose colour, from below upwards, changed from leek-green to greenish black. Covered with a steel-grey metallic crust. Fracture, moderately shining, of a greasy lustre.

#### No. 47. HYACINTH; from Ceylon.

- n) CH. Cr. Its colour became greyish-white. The crystals in some degree coalesced; but remained in other respects unchanged, except their transparency being diminished..—No. L. of W.
- b) CL. Cr. Such of the crystals as were in contact with the crucible, united with it by fusion, throwing up a ferruginous crust. The others were loosely conglutinated together. The colour, in part, passed into a wine-yellow.

No. 48. CAT'S-EYES, grey-white; from Ceylon.

- a) CH. Cr. Became foft, grey, dimmed, and opake by the action of the fire.—No. L. of W.
  - b) CL. Cr. The same change.

No. 49. CAT'S-EYE, red; from Malabar.

- a) CH. Cr. Like No. 48. a)
- b) CL. Cr. The fame.

## No. 50. LABRADOR-HORNBLENDE (Labrador-) stein).

- a) CH. Cr. Fused into a compact glass, of great lustre, pellucid in small splinters, of a pale-grey colour, with very minute, detached grains of iron.—L. of W. 0,04.
- b) CL. Cr. A compact, dusky-white scoria, transparent on the edges.

#### No. 51. LAPIS LAZULI, deep-blue.

- a) CH. Cr. A dense, grey, semi-pellucid glass; overlaid with grains of iron.—L. of W. 0,12.
- b) CL. Cr. A dense, brownish, black glass, with separate grains of iron upon its surface.

#### No. 52. LAVA, loose, frothy; from Vesuvius.

- a) CH. Cr. Changed to a compact glass, of a greenish-grey tinge, containing granular particles of iron; and transparent on the edges.—L. of W. 0,08.
- b) CL. Cr. A compact, brownish-black glass, having rusty spots on the upper part.

#### No. 53. LEMNIAN EARTH, common. (Bole).

- a) CH. Cr. A dense, deep-greenish-grey glass, covered with a crust coloured like rust of iron, and some ferruginous grains.—L. of W. 0,25.
- b) CL. Cr. A compact greenish-black glass; shewing at the top light-brown points, lying slat.

## No. 54. LEPIDOLITE (Lilalite); from Rosna in Moravia.

- a) CH. Cr. Produced a pale-grey, dense, semi-pellucid, very hard glass; partially covered with a grey ferruginous crust.—L. of W. 0,17.
- b) CL. Cr. Afforded a greyish-white, transparent glass, with very small bubbles; and on the upper parts covered with a light-brown crust, of a lustre nearly metallic.

No.

No. 55. LEUCITE (not yet affected by volcanic fire); from Vesuvius.

a) CH. Cr. Outwardly a commencement of fusion; the infide little altered, and still very glossy. The horn-blende which it contained within, was melted into separate, black, minute drops.

b) CL. Cr. Exactly the fame.

No. 56. MARBLE, white; from Carrara.

a) CH. Cr. Was converted into quicklime.

b) CL. Cr. Changed into a dense, clear, hard, pale grass-green glass.

No. 57. PLASTIC SILICI-MURITE (Meerschaum, Keffekil of Cronstedt); from the Levant.

a) CH. Cr. Not altered; only rendered more meagre and indurated by ignition; very firongly adhering to the tongue.—L. of W. 0,30.

b) CL. Cr. The same.

No. 58. OBSIDIAN, black; from Mount Hecla in Iceland.

a) CH. Cr. A greenish-black glass, of great splendour; pellucid in small pieces, outwardly with a grey incrustation.

b) CL. Cr. Melted into a dense, black-brown glass; transparent only in its smallest splinters, and of a conchoidal fracture.

- No. 59. OBSIDIAN, blackish-grey, transparent; from Lipari.
- a) CH. Cr. Gave a glass, pellucid in larger lumps; of a somewhat dusky, pale, grass-green hue, containing airbubbles, and externally covered with a grey turbid crust.
- b) CL. Cr. Fused into a clear, pale-black-greenish glass, with separate bubble-holes.

No. 60. OBSIDIAN; from Tokay.

- a) CH. Cr. Like No. 59. a)
- b) CL. Cr. Like No. 59. b)

No. 61. OLIVIN; from Greenland.

- a) CH. Cr. The grains black, opake, finely glazed, and conglutinated.
- b) CL. Cr. Almost the same change, and coalesced with the sides of the crucible, which it powerfully attacked.

No. 62. OLIVIN; from Habichtswalde.

- (a CH. Cr. As No. 61. a); only a little more firmly coalesced.
  - b) CL. Cr. As No. 61. b)
- No. 63. OLIVIN; from Rittersdorff, in the middle mountains of Bohemia.
- a) CH. Cr. The concretion of the grains stronger; also strongly glazed, and of a dirty leek-green.

b) CL.

#### b) CL. Cr. Like No. 61. b)

#### No. 64. OLIVIN; from Unkel.

- a) CH. Cr. Its grains were covered with a greenish-black glaze, cemented together, and crossed by a white mass, in some places crystallized in a delicate capillary form. Their outer sides were invested with grains of iron.—L. of W. 0,02.
- b) CL. Cr. Were fused into one glossy, somewhat porous mais, which, in the upper part, was crystallized in a radiated form, with a brownish-grey tinge; but in the fracture it was partly greenish-white, partly grass-green.
- No. 65. OPAL (femi-opal), brown-red; from the Telkebanya mountains.
- a) CH. Cr. Without alteration as to form, Externally black-grey, dull, and in every part covered with different finall grains of iron. In the fracture, brownish-grey, dull, and uneven.—L. of W. 0,18.
- b) CL. Cr. Little changed in the form. Externally resembling the specular or grey iron-ore (Eisenglanz). Its fracture black, glittering, and in a small degree porous.
- No. 66. OPAL (semi-opal), yellow; from the same place.
- a) CH. Cr. Figure unaltered; its colour turned greyish-white, and it was much disposed to fly in pieces. Some lustre on the outside; in the fracture, dull and earthy, of a fine grain.—L. of W. 0,06.

b) CL. Cr. The fame changes; together with a some-what brighter lustre.

No. 67. OPAL, semi-opal of a verdigris-colour (Helio-tropium?); from Greenland.

- a) CH. Cr. Was rendered foft, its fracture of a light-reddish-brown, speckled with a copper-red; glittering, and exhibiting dim-white points and veins.
- b) CL. Cr. Rendered not quite so soft by the ignition; and it acquired a liver-colour, with white spots.—L. of W. 0,06.

#### No. 68. PITCH-STONE, yellow; from Meissen.

- a) CH. Cr. A greyish-white glass; though clear in itself, yet full of froth-bubbles. The outer surface prefented a deep-grey, shining crust.
- b) CL. Cr. The fame; but without the external incrustration.
- No. 69. PITCH-STONE, blue (fo styled); from Menil-Montant, near Paris.
- a) CH. Cr. Became foft, yellowish-white, and split or cleft in the manner of slate.
- b) CL. Cr. The fame changes; except its colour turning light-brown.—L. of W. 0,08.
- No. 70. SHISTOSE PORPHYRY; from Schlossberg near Toplitz. (Its chief mass the Klingstein, as it is called).

- a) CH. Cr. Run into a dense, very shining glass, of a grey tinge inclining to deep-green; transparent in small fragments, and inlaid with detached, nearly tin-white grains of iron.—L. of W 0,05.
- b) CL. Cr. A compact brownish-black glass, with transparent edges, and a conchoidal fracture.

## No. 71. PORCELAIN JASPER, yellow; from Bohemia.

- a) CH. Cr. Suffered no alteration in its form; but was rendered fomewhat contracted, of a deep steel-grey, and dull.
- b) CL. Cr. Figure unchanged; externally yellowishbrown; in the fracture, black and glittering.

#### No. 72. PRASE; from Breitenbrunn.

- a) CH. Cr. Its form unaltered; externally of a grey-white, shining, inlaid with transluded grains of iron. Its fracture, greenish-white, of a faint lustre, and uneven. Totally opake.—L. of W. 0,03.
- b) CL. Cr. The form likewise unaltered; externally of a smutty-greenish white, glossy, and spotted with minute drops resembling pitch. Fracture grey and dim.

#### No. 73. QUARZ, red; from Rabenstein.

- a) CH. Cr. No change in the figure; colour entirely pale reddifh-white; flightly transparent; and invested with a delicate glazing.—L. of W. 0,03.
  - b) CL. Cr. The fame.

#### No. 74. RUBY, rose-red, oriental.

- a) CH. Cr. No alteration; except its furface having become a little dimmed.—Also without L. of W.
- b) CL. Cr. Entirely unchanged. Its colour even feemed to be rendered still purer and more lively than before ignition.

#### No. 75. MUSCOVY GLASS (Glift, Mica); from Siberia.

- a) CH. Cr. In order to inclose it in the crucible, feveral lamellas were rolled up. The outer ones became grey, glazed and brittle; the inner ones black, like tinder, and continued flexible.—No. L. of W.
- b) CL. Cr. Every one of the lamellas thoroughly hardened by the ignition, glazed, brittle, rendered nearly fonorous. Colour changed to a greyish-white; the surface in part also light-brown.—No. L. of W.

#### No. 76. SAPPHIRE, azure-blue; from Ceylon.

- a) CH. Cr. Without alteration; except the furface, which became a little dusky, and dim and muddy.—No loss of weight.
- b) CL. Cr. Likewise unaltered. However, the colour was rendered in some pieces paler, and at the same time slightly opalescent.

## No. 77. PRISMATIC SHOERL, black, longitudinally ftreaked; from Cornwall.

a) CH. Cr. Little change in the figure. Outwardly, still preserving, in part, the prismatic form, with grains of iron exuded

exuded. Fracture grey, of but little gloss, resembling that of fat.—L. of W. 0,09.

- b) CL. Cr. Imperfectly fused; on the upper part brown, with glittering points. Fracture of a blackishgrey, slightly resplendent, with a greafy lustre, and exhibiting fine pores.
- No. 78. SHOERL, black crystallized, in columns of nine fides; from St. Gotthard.
- a) CH. Cr. Externally ash-grey, and very much shrivelled. In the fracture presenting a compact, smokegrey, moderately shining scoria; with several large bubbles, containing on the inside differentiated granular particles of iron.—L. of W. 0,08.
- b) CL. Cr. Fused into a tough, pale, olive-green slag, of a moderate gloss like fat; with several large air-bubbles.
- No. 79. SHOERL, black, in large hexagonal columns; from Greenland.
- a) CH. C. Converted into a scoria of a greenish-grey tinge, and transparent fragments. Its surface was coated with a dusky crust, and scattered grains of iron.—L. of W. 0,07.
- b) CL. Cr. An olive-green flag, transparent in thin splinters, of considerable compactness, and a wrinkled surface.

No. 80. SERPENTINE, blackish; from Zöblitz.

- a) CH. Cr. Indurated; externally covered with a ferruginous crust, together with small grains of iron. In the fracture, splintery, dull and of a grey colour.—L. of W. 12.
- b) CL. Cr. Rendered hard. The furface glittering, glazed in part, and paffing from iron-black to a copper-red. Towards the edges of the fracture likewise iron-black, but in the middle of a pale greenish-grey; smooth and dull.

#### No. 81. EMERALD; from Peru.

- a) CH. Cr. Entered into an imperfect fusion, and preferved its green colour, though somewhat souled. It also was rendered opake, and presented detached minute grains of iron.
- b) CL. Cr. A clear, greenish-white glass, with a few radiating points,

#### No. 82. EMERALD? oriental; (perhaps green fapphire?)

- a) CH. Cr. Quite unaltered in shape. The colour was rendered somewhat duller, and verging towards grey. The surface partially covered with a rough crust; some pieces reslected changeable variegated colours.
- b) CL. Cr. Figure and lustre as before. Turned opake. The green colour in part passed to a white, and in some pieces the variegated reslection of colours was still more distinct.

No. 83. SPINELL (Ruby).

- a) CH. Cr. Suffered no change, excepting that its furface became fomewhat muddy and foul.—No loss of weight
- b) CL. Cr. Part of it was imperfectly melted to a blackish-brown scoria, into which were cemented the other pieces, whose colour and transparency were unimpaired.
- No. 84. ACTYNOLITE (Strahlstein) common, green; from St. Gotthard.
- a) CH. Cr. Externally covered with a ferruginous crust, and numerous grains of iron. The inside shewed a grey and dull scoria, full of bubbles.—L. of W. 0,04.
- b) CL. Cr. Converted into a fibrous flag, of a greenish-grey fracture, and a brown surface, crystallized in a radiated form.
- No. 85. ACTYNOLITE, common, leek-green; from Petersburg. (Swed. Hornblenda).
- a) CH. Cr. Like No. 84. a); only with but few grains of iron in the furface, and with acicular crystals in the froth bubbles.—L. of W. 0,04.
- b) CL. Cr. A leek-green, and at the top red-brown, compact scoria; of a fine striated fracture, and efflorescent crystallization.
- No. 86. ACTYNOLITE, common, in feparate parallel prisms; from *Carinthia*.
- a) CH. Cr. A dull, bluish-grey scoria, full of bubbles and its surface inlaid with grains of iron.—L. of W. 0,04.

- b) CL. Cr. A dense, greenish-white, and in the fracture indistinctly radiated slag. On the upper surface crystallized in interwoven, reticular, fine, brown needles.
- No. 87. GLASSY ACTYNOLITE; needle-fhaped, of an intermediate colour between deep mountain-green, and black-green; from Taberg.
- a) CH. Cr. As No. 86, a). Its crust had in some places a cupreous lustre.—L, of W. 0.12.
- b) CL. Cr. Fused into a dense, greyish-white, opake scoria, marbled of a brown-yellow at its top.
- No. 88. GLASSY ACTYNOLITE, acicular, white; from Taberg.
- a) CH. Cr. A greyish-white mass, sufed in a spherical form; on the upper part with separate, recumbent, shining radiations; on the under part mixed with grains of iron. Fracture uneven, dull and rough; in parts striated.—L. of W. 0,20.
- b) CL. Cr. A greenish-white, dense scoria, with a glittering greenish-yellow very fine efflorescent surface of small stellular points. Fracture finely sibrous and resplendent.
- No. 89. ACTYNOLITE, olive-green, in prismatic crystals; from Dauphine.
- a) CH. Cr. The pieces did not fuse together, but were merely conglutinated firmly. External surface, iron-black, with small ferruginous grains, oozed through. Infide steel-grey, fine earthy, and dull.—L. of W, 0,15.

b) CL.

- b) CL. Cr. Melted into a highly resplendent glass; of a black-brown colour; flat conchoidal fracture, and transparent splinters.
- No. 90. ACTYNOLITE, crystallized in prisms, deep blackish-green; from Zillerthal in Tyrol.
- a) CH. Cr. Fused into a spherical, moderately splendid, opake scoria, of a bright greenish-grey colour, and perfectly radiated fracture, surrounded with grains of iron.—L. of W. 0,06.
- b) CL. Cr. A firongly resplendent, compact, opake flag, internally almost apple-green; of a conchoidal fracture, and yellow surface, mixed with brown.

#### No. 91. STRONTIANITE.

- a) CH. Cr. Form unaltered. Hardened by ignition; rendered dull, and very caustic.—L. of W. 0,31.
  - b) CL. Cr. A clear, bright grass-green glass.
- No. 92. TALC (of the magnefian or muriatic genus); greenish-white; from St. Gotthard.
- a) CH. Cr. Became hard; fplit like flate; grey white; in two places flightly united with the crucible by fusion.
- b) CL. Cr. Rendered yellowish-white; hardened by the ignition, and acquiring slaty rifts.—L. of W. 0,05.

#### No. 93. TALC, Venetian.

a) CH. Cr. Indurated, flaty, bluish-grey; in part with a thin red covering.—L. of W. 0,08.

b) CL. Cr. The fame change. Its colour brown, refembling decayed mica.

#### No. 94. TOPAZ; from Brafil.

- a) CH. Cr. Rendered white, dull, untransparent; of a fine earthy and longitudinally striated fracture.—L. of W. 0,20.
  - b) CL. Cr. The fame; with thin flakes, burst off.

No. 95. TOPAZ; from Schneckenstein.

- (a) CH. Cr. As No. 94, a).—L. of W. 0,20.
  - b) CL. Cr. As No. 94. b).-L. of W. 0,20.

No. 96. TREMOLITE, radiated; from St. Gotthard.

- a) CH. Cr. Ran into an opake, grey-white, round feoria; of a foliated texture, and a radiated crystalline furface.—L. of W. 0,05.
- b) CL. Cr. A compact, greenish-white slag, with little lustre, and of a radiated fracture.
- No. 97. TRIPOLI; from Menil-Montant, (the matrix of what is called blue pitch-Rone.)
- à) CH. Cr. An indurated, very contracted, black-grey, finely porous scoria.
- b) CL. Cr. Its outer furface brownish and glittering; its internal surface, or fracture, yellowish-grey, dull, and porous like sponge.—L. of W. 0,20.

## No. 98. TOURMALINE, green, transparent; from Brafil.

- a) CH. Cr. Hardened by the ignition. The fides compressed inwards. Externally black-brown; internally greenish-grey, opake and dull.—L. of W. 0, 10.
- b) CL. Cr. The fame change; but of a blacker tinge. The part of the crucible, in contact with it, covered with a brown glaze.

#### No. 99. TOURMALINE, black; from Spain.

- q) CH. Cr. Hardened, and the cryftals conglutinated. Outfide black, with crofs rifts and dull; infide dim greywhite. Fracture, conchoidal. Slight glofs of the greafy kind.—L. of W. 0,15.
- freel-grey, but with rather less lustre, and with fine spores.

#### No. 100. TOURMALINE, black; from Zillerthal.

- a) CH. Cr. Assumed a very irregular shape. Externally like No. 99, a); inwardly, of a conchoidal fracture, a smoky grey colour, and greasy lustre.
- b) CL. Cr. Tough; diffused by melting; light-brown, opake, and of a middling greafy lustre.

## No. 101: UMBER, (brown iron-ochre); from the neighbourhood of Cologne.

a) CH. Cr. Gave a dense, opaline glass; of a bluishgrey in the fracture, transparent when in small splinters, and of a strong greasy lustre. It was coated with a greywhite white crust, finely dotted by very minute froth-bubbles. At the bottom was one considerable grain of iron, which separated of itself.—L. of W. 0,33.

b) CL. Cr. Fused into a solid, black glass; whose upper part was covered with a crust of the specular iron-ore, (Eisenglanz) very delicately efflorescent, and radiated in a stellular form.

#### No. 102. UMBER; from Cyprus.

- a) CH. Cr. Like No. 101, a) except that its crust was still more minutely dotted, and the inward colour of a clear smoke-grey.—L. of W. 0,33.
  - b) CL. Cr. Like No. 101. b)

#### No. 103. VESUVIAN, light-brown.

a) CH. Cr. A dense, clear, strongly resplendent, nearly colourless glass. The outer surface was rather muddy, and was formed into groups of regular crystals (drusigt) exhibiting very minute short protuberances, each of which ended in a point, by means of four triangular, exceedingly sine striated facets. Numerous grains of iron were imbedded in its under surface.—L. of W. 0,25.

b. CL. Cr. A compact, very dark olive-green glass; of a bright luftre, and flat conchoidal fracture.

No. 104. VOLCANIC ashes; (from the eruption of Mount Vesuvius, collected at Naples in the summer of 1794.)

a) CH. Cr. Melted into a compact glass, of a dirty olive-green; small fragments of which transmitted light. It contained some pieces of iron.—L. of W. 0,10.

b) CL.

- b) CL. Cr. A dense, brownish-black glass.
- No. 105. WACKE (a variety of basalt, commonly ranked among the species of argillaceous earths); from foachimsthal.
  - a) CH. Cr As No. 7. b).
  - Wore. The fame specimen was again put into the charcoal-crucible, after it had been separated from the grains of iron. When taken out, it was tuberous or knobby. The surface presented a glittering black-brown incrustation, whose fracture had a slight lustre. But the interiour mass had become pale-grey, and denser than before.
  - b) CL. Cr. The same change as No. 7. b)
- No. 106. FULLER'S EARTH (Smectis) genuine; from Hampshire.
- a) CH. Cr. A compact opake scoria of a dull grey, with many grains of iron.—L. of W. 0,25.
- b) CL. Cr. A dense, blackish-green scoria. Its smooth surface exhibiting red dots.

#### No. 107. WITHERITE; from Anglezark.

a) CH. Cr. In experiments repeatedly made with this substance, the inner charcoal-crucible was found consumed for the greatest part. Hence the witherite always entered into an impersect susion with the contiguous part of the clay-crucible, which served as a case to the charcoal-crucible.

b) CL. Cr. A green, somewhat turbid, and frothy glass.

No. 108. ZEOLITE, compact, filiceous, (Prehnite); from Scotland.

- a) CH. Cr. Fused into a compact, deep-grey, opake scoria. Fracture, imperfectly conchoidal, and highly glittering. Coated with a ferruginous crust; and containing a few minute grains of iron.—L. of W. 0305.
- b) CL. Cr. An opake dense slag. Its surface olivegreen; the inner mass, celadon-green, and the fracture glittering.

No. 109. ZEOLITE, radiated; from Ferroe.

- a) CH. Cr. Swelled up into an ill-shaped, greyish-white, transparent scoria; full of froth bubbles.—L. of W. 0,16.
- b) CL. Cr. The same; but as white as snow.
- No. 110. ZEOLITE, volcanic grey; (according to Fichtel—according to others, zeolitic pitch-stone) from the Mount Pap-Lasso, near Telkebanya.
- a) CH. Cr. A glass of a dim, black-grey colour; of a clear transparence on the edges; of a greasy gloss in the fracture; and shewing separate bubbles. It also had very small grains of iron in several parts of its external surface.—L. of W. 0,05.
- b) CL. Cr. Yielded a dense, bright greyish-white, transparent, but not thoroughly clear glass; rendered turbid by very minute froth-bubbles. Its smooth surface pos-

fessed a great splendour, and was marked with dispersed brown-red spots, resembling agates.

No. 111. ZEOLITE, volcanic red; from the fame place.

- a) CH. Cr. Like No. 110. a)
- b) CL. Cr. Like No. 110. b); only somewhat more turbid.

No. 112. CIRCON (Jargon); from Ceylon.

- a) CH. Cr. No change, excepting that its colour turned white-grey, and its furface became a little more turbid.—Also no L. of W.
- b) CL. Cr. Likewise unaltered. The greenish colour had almost disappeared, and in its stead succeeded a reddish, bluish, and in part perfectly white one. Several pieces emitted a whitish lustre.—No loss of weight.

Concerning the utility which these experiments on fusion may afford in various respects, I shall make only one or two remarks.

On reviewing the division of stones and earths into fufible and infusible, which has been hitherto adopted, we observe that several of them are classed among the first; which,
however, are not susible of their own accord, but acquire
that property only by the co-operation of extraneous causes.
Thus, if we observe the Strontionite (No. 91), the Compound-spar (No. 16), Sidero-calcite (No. 20), Marble,
(No. 56), and in general all the species of calcareous
earth, to vitrify in the melting-vessels, it is owing to the
argillaceous earth of the clay-crucible, which by its contact
effects the susion of those stony matters, which, when a
alone, are insusible.

Will Wal

With respect to many other substances, the cause of their vitrification is their ferruginous contents; for oxyd of iron likewise promotes the sussion of many compositions, otherwise not vitrishable. This vitrishcation, therefore, cannot take place in charcoal-crucibles; because in these, the calx of iron loses its vitrescent property, by being reduced to reguline iron, and hence is rendered incapable of continuing in chemical solution or combination with unmetallic-earths. It then separates from them by a kind of eliquation.

An inftance of this is afforded by the Bafalt, (No. 6—10), usually represented as a body, which very easily melts into a black glass. But this suffibility of basalt obtains only when its ferruginous part finds no opportunity to be reduced and to separate: for after this is withdrawn, the remaining portion of basalt is no longer vitristable. It now appears, if examined by a lens, as a body almost wholly corroded; and it is not converted into a scoria, unless after continued exposure to the most violent fire.

It is worth remarking, that, in the charcoal-crucible, not only is the iron of such fossils, as contain it in a very slight quantity, as Pumice-stone (No. 15), Boracite (No. 19), Mica (No. 38), completely reduced; but also, that even some species of stones, which in no manner undergo real sussion, nay, which hardly seem to become softer, as the Ligniform Asbestus (No. 11), Chrysolite (No. 25), Brown-red Semi-opal (No. 65), Prase (No. 72), and Serpentine (No. 80), do nevertheless deposite, as it were by exsudation, most part of their iron.

The proportion of the ferruginous contents thus discovered, may serve at the same time to determine in dubious cases the classification in the mineralogical system. That is to say, it may affish to decide, whether a fossil, whose

pro-

proportion of metallic parts is as yet unknown, should obtain a place in the class of earths and stones; or, whether it ought to be ranged in the genus of iron-ores.—Such is the case with *Umber*. Of one hundred parts of umber from *Cyprus* (No. 102), there remained 67; and the iron, reduced from this residuum, amounted to 37; but the vitreous scoria, only to 30.—Of one hundred parts of *umber* from *Cologne*, there likewise remained 67, of which 35 were iron, and 33 were scoria. This mineral, therefore, as much deserves a place under the genus of iron-ores, as several other iron-ores, less rich in ferruginous contents. It may be considered, either as a particular species of the brown iron-stone; or as a variety of brown iron-ochre.

Besides, the trials made with fire may be of some utility with regard to those fossils, concerning which the opinions of the learned are yet divided, with regard to the means employed by nature for their formation. I even think, that in this branch of geological refearches, the experiments made by means of fire, are rather more decisive than the analysis in the moist-way. Although it is quite contrary to my intention to enter into this dispute, yet I think myself obliged to state my own private opinion respecting this subject, independent of the authority of others; which is, that I cannot rank among the products of fire, either the genuine basalt, or its kindred wacke, or the porphyric-flate. In this perfuafion I am confirmed by perfonal inspection of basaltic districts, especially of the Bohemian middle mountains; as well as by the habitudes of the above minerals in fire. No. 6-10; 105; 70.

On the contrary, as to what relates to the generation of the Obsidian (No. 58, 60), Pumice-stone (No. 15), and pretended Volcanic Zeolite (No. 111, which last is reckoned by some among the Pitch-stones), &c, I willingly renounce

my own opinion; adding only, that, on confidering the arguments for and against their volcanic origin, the circumstance of the obsidian and pumice-stone giving in fire exactly the same products, should not be disregarded; and also, that both these fossils, not only accompany each other at Lipari, but likewise frequently occur actually blended.

As the chemical analysis in the humid way is embarrassed with many difficulties, that check the progress of our knowledge of the constituent parts of fossils; the speedier examination, by means of fire, of a fosfil, not yet analysed, may ferve as a previous hint for affigning to it its proper place in the systematical arrangement. It may also tend to correct the claffification of feveral minerals whose characters are not fufficiently distinct, or perhaps have led to error. So, for instance, the above results plainly shew, that the Cats-eye is not a fel-spar (No. 48, 49); that the Leucite does not belong to the garnets, and as little to the fel-spar (No. 55); that the Telkebanya-stone, or brown-red Semi-opal, is not allied to the vitrifiable pitch-stones, among which it has been ranged on account of its perfect opacity (No. 65); and that the Granatite cannot be classed under the garnets (No. 41); nor the Cyanite under the striated shörls (No. 28); non the Chlorite, under the varieties of mica (No. 23.)

However, the inferences drawn from these experiments, should not be carried too far; nor should a decisive conclusion be made on the constituent parts of a fossil, merely from its changes in the fire. For, in this respect, the analysis in the humid way is absolutely the only safe guide.

# Scenes, the hardness of which does not surpais that of fint, weigh then no more t. II at hith. But such as are harder than fint, acquire an increase of weight; which in

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Therefore, as this addant of weight mult, of courie, be again subtracted from the time of the coast tuent parts of the decomposed body, an graft chemical knowledge of

### A chine BLACK-GREY FLINT.

(Common Flint; Feuerstein of the Germans.)

heric cligible for the granding of hard Roner, if, behites the filex, its chief ingredient, is contained other earths in that

In order to reduce to the requifite most subtle pulverulent state the harder kinds of stones, which are to be subjected to a chemical analysis, I make use of a grinding concave shallow vessel or bowl, wrought, as well as its appropriated mullar, of black-grey flint. The body, which is to to be finely ground in it, being previously pulverized in a polished steel-mortar, gently ignited and accurately weighed, I moisten with water, and continue the trituration, until the stone is reduced to an impalpable powder. A shorter or longer time is necessary for this operation, according to the degree of hardness; so that 100 grains of the more indurated species of gems often require triturating for three or four hours. After the finely powdered mass is again desiccated in the air, or in a gentle warmth, I ignite the powder, carefully collected from the triturating-dish, in a filver or porcelain-crucible, with a low heat, and weigh it once more.

Stones,

Stones, the hardness of which does not surpass that of flint, weigh then no more than at first. But such as are harder than flint, acquire an increase of weight; which in some gems, as the sapphire, adamantine-spar, and chrysoberyl, often amounts to from 10 to 13 per cent.

Therefore, as this addition of weight must, of course, be again subtracted from the sum of the constituent parts of the decomposed body, an exact chemical knowledge of the substance, of which the grinding vessel consists, is indispensable. And, no doubt, common slint would be little eligible for the grinding of hard stones, if, besides the silex, its chief ingredient, it contained other earths in that quantity, which is stated by mineralogists; and of which aluminous earth is said to make up from 18 to 20 parts in the hundred.

But from an exact and repeated analysis of this slint, I am convinced that the quantity of foreign earths, which are here combined with the silex, is far less considerable, and that in general the sum of them only amounts to one grain. On this account, and considering the small number of grains abraded from the slint mortar, it would appear a superfluous nicety, to bring into calculation the small fractional parts of the other earths, besides the siliceous.

- a) Five hundred grains of common slint, coarsely bruised, were ignited for half an hour in a covered crucible. They lost, by this, five grains of weight, and turned greyish-white.
- b) A Hundred grains of flint, reduced to the finest powder, were mingled with three times their weight of caustic pot-ash, and exposed to a red-heat in a silver-crucible for halt

half an hour; by which management, however, the mixture did not fuse, but continued a loose, friable mass. When covered with water, it was all diffolved, without any refidue, and afforded a somewhat turbid liquor.

- c) By over-faturating this folution with muriatic acid, the filiceous earth was precipitated; which, after a due digestion, was separated, washed, and ignited .- It weighed 97 grains.
- d) The acid fluid, thus feparated, when faturated with carbonat of foda, let fall a brownish earth; which re-disfolved in muriatic acid, and left filiceous earth, weighing one grain after ignition.
- e) The remaining muriatic folution afforded, with cauftic ammoniac, a brown, mucilaginous precipitate; which, when added, while yet moist, to caustic lye, deposited oxyd of iron, weighing after ignition one quarter of a grain.
- f) When this portion of iron had been separated, I mixed the caustic lye with muriatic acid to excess. Being then saturated with mild salt of tartar, it was put in a warm place. A fmall portion of earth fell down; which, after gently drying, weighed one half grain, and its folution in fulphuric acid afforded aluminous crystals. This aluminous earth would have weighed one quarter of a grain in its dry state.
- g) The edulcorating waters, after being collected, evaporated to dryness, and the residual saline mass, again disfolved in fresh water, deposited three quarters of a grain more of an earth, which diffolved in muriatic acid, with effervescence, and yielded selenite or gypsum, on dropping fulphuric acid into it. It was consequently calcareous earth,

which,

which, if free from carbonic acid, would have amounted to half of a grain. morelled not bufer but communical a legis. E

Hence the constituent parts of common flint amount in one hundred to

Ignited filex c) . 97 } d) . 1}.	98,
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#### CHEMICAL EXPERIMENTS

ON THE

#### ADAMANTINE SPAR.

#### FIRST SECTION\*.

NATURE, inexhaustible in its riches, has intended, as it were, to keep in activity the ardour of Naturalists, in the discovery, examination, and arrangement of the fossil products, by presenting new species that have remained hitherto unknown, and whose proper place has been too frequently mistaken in artificial classifications. This truth has been confirmed, in an eminent degree, by the adamantine spar.

The native places of this stone are China and Bengal; and from each of these countries it was first brought to Europe, for the celebrated cabinet of Charles Francis Greville, Esq. in London. The denomination of adamantine spar, given to it by English Naturalists, is grounded not only on its uncommon hardness, similar to that of diamond;

<sup>\*</sup> Read in the Royal Acad. of Sciences at Berlin. See Recherthes chymiques fur le Spath adamantin; in the Memoires de l'Acad. royale ete, Août 1786, jusqu' à la fin de 1787. Berlin 1792.

but also on its application; for the Chinese and Indian lapidaries make use of the powder of this stone instead of the real diamond-powder for grinding.

The first public notice taken of the adamantine spar which I know of, is contained in the second Volume of Sage's Analyse chymique et concordance des trois regnes; where this writer states the above sossil to be a granite, composed of sel-spar, black-shorl, and quarz. A more accurate account of it, together with a description of its external appearance, was afterwards given by de la Metherie and Abbê Hauy in Rozier's Journal de Physique, for January and March 1787.

But as no Chemist has ventured to undertake its chemical analysis, Mr. Greville was so obliging as to sacrifice a quantity of this substance, in his possession, sufficient for its examination, and to send it me for that purpose.

The adamantine spar presents two distinct varieties, according to the two different countries which give it birth. The first, which is found in China, when regular, assumes a columnar form of six sides, without terminating points. The size of the specimens which I have seen, was from an half to a full inch in height, and three quarters of an inch in thickness.

The colour of this stone is grey, of various shades, partly verging to the brown of hair. The entire pieces are opake; but in thin lamellas, and on the edges transparent. Its fracture is glossy, and exhibits a fine spatose or soliated texture; on account of which, even its outer surface appears finely striated. Its lateral facets are mostly coated with a delicate, firmly adhering crust of micaceous scales of a silvery lustre, and in some places intermingled with parti-

cles of red fel-spar.—One specimen was also covered with a delicate yellow fulphur pyrites.

This stone is exceedingly hard. For this reason, it not only cuts glass with as great facility as diamond, but it also scratches rock-crystal and other hard stones, and is employed, as already mentioned, for cutting and polishing even gems.

Its specific gravity I found to be 3,710.

An accidental characteristic mark of this Chinese adamantine spar is, that it contains magnetic iron, disseminated in small crystalline grains, which are easily separable by means of the load-stone, if the stone has previously been bruised to a moderately sine powder.

The fecond variety, or Indian adamantine-spar, from Bengal, called by the natives Corundum, is distinguished from the Chinese by a whiter colour, by a more decidedly sparry texture; and by the magnetic iron, which it likewise contains, consisting of still smaller grains, but not interspersed within its substance, but merely adhering to its surface.

With the Chinese Adamantine Spar I made the following Chemical Experiments.

By strong ignition for an hour it lost 1; per cent. of weight; but suffered no alteration, except having become a little whiter. Before the blow-pipe upon charcoal, it was

not in the least attacked, either by soda, or by borat of soda; or by the compound of phosphat of soda and ammoniac (phosphoric salt of urine.)

In order to guard against accidental impurities, I bruised the stone on the anvil, between many sheets of strong paper. I then picked out the purest pieces; heated them to redness, and quenched them in water. However, this operation being several times repeated, was found useless; and the hardness of the stone was not at all thereby diminished. It was next triturated in an agate mortar to the sinest powder; and upon 300 grains, or sive drachms of this powder, introduced into a retort, twice its weight of aqua regia was poured. By strong digestion, I obtained from it a goldenyellow tincture of iron. This digestion was once more repeated with a fresh quantity of the same acid. I then precipitated the dissolved iron by caustic ammoniac; which precipitate, after edulcoration and ignition, was all attracted by the load-stone.

My next step was to examine whether the decanted stuid contained calcareous earth.—For this purpose I combined it with mild ammoniac; but no trace of this earth appeared. Therefore the acid had only extracted that portion of iron, which is simply disseminated in the adamantine spar; but does not belong to its composition.

The powder remaining after the extraction of the iron was of a bright ash-grey. This I mixed with double its weight of salt of tartar\*, and ignited it in a filver-crucible, during two hours in a brisk fire. But on softening again this mass by distilled water, I soon perceived, that no resolution,

<sup>\*</sup> Pot-ash, or vegetable alkali, prepared from tartar.

or feparation of parts, had taken place in the intrinsic mixture, or composition of the stone: nor did the alkaline solution let fall any precipitate, when saturated with acids.

Convinced by other experiments, that the caustic fixed alkalis have a stronger resolvent power, than the mild over stones of a stronger texture, I resolved to repeat the operation with the caustic alkali. With this view I prepared caustic soda, with all the precaution necessary for obtaining it in a perfectly pure state.

Equal parts of this caustic salt, and of the powder of adamantine spar, were subjected to ignition in a silver-crucible for the space of two hours. After this, the calcined mass, which had become very compact and hard, was triturated with distilled water; super-saturated with muriatic acid, and digested. The acid extracted merely a pale yellow tincture, which still contained a slight ferruginous impregnation; but nothing of an earthy nature. When the residual powder was again washed, and ignited, it was of a light grey-white colour, and weighed 240 grains. So that 60 grains, making the sisth part of the sirst weight of the crude stone, must be taken for the iron disseminated in, and now separated from it by acids.

These 240 grains I mixed with four times their weight of caustic mineral alkali; and ignited them in a crucible made of filver, as long as the vessel would bear it, without itself susing. After refrigeration, the mass was so firm and so hard, that in order to bring it on the filter, I was under the necessity of softening it by long tedious boiling in distilled water. The alkaline solution, saturated with muriatic acid, now dropped a white, very loose earth; which, from previous conjecture, I then imagined to be filiceous. But this was not the case, for it was rapidly and clearly redisting the same and the case, for it was rapidly and clearly redisting the same all the same and the case.

diffolved by a flight excess of acid, and proved to be rather aluminous on farther trial. And by accurately saturating the solution with salt of tartar, I reproduced it again in the form of a precipitate, and collected it.

The powder, left on the filtering-paper, had an ifabella-yellow colour, and had become loofer. I poured upon it four parts of aqua regia; but it foon formed with it a thick gelatinous coagulum. Having added four parts more, I digefted the mixture in a boiling heat. Which being done, it was diluted with hot water, and, after filtration, faturated with falt of tartar. By this management a white loofe earth precipitated, and was aluminous, like the preceding.

I next repeated the same operation with the 140 grains of the powder of this stone that remained in the last-mentioned process: that is to say, I added four parts of caustic soda, and heated it to redness for sive hours in a silver-crucible. As in the preceding experiment, so in this, the mass became exceedingly hardened, and of difficult solution, even in boiling water. Its filtered lye likewise deposited, on the addition of muriatic acid, a white loose earth; which, in the same manner, entirely dissolved without any turbidness, by an excess of the acid. Having been again precipitated by mild alkali, I collected and added it to that which was obtained in the last process.

In the fame manner, as mentioned above, I treated the refidue that remained behind on the filter after the separation of the alkaline lixivium, by digesting it in aqua regia; and the small portion of earth, extracted from it, was likewise precipitated by falt of tartar.

The undecomposed part of the powder, which at this period weighed 103 grains, I subjected a second time to calcination,

nation, during five hours, being previously mixed with a quadruple proportion of caustic alkali. The result agreed with that of the foregoing process. From the filtered alkaline solution of the mass, softened with difficulty, acids threw down a slight quantity of loose earth; which was re-dissolved when the acid was added to excess. Having been again precipitated by the addition of alkali, it was then collected.

I next put the edulcorated residue, weighing now but 92 grains, in digestion with six parts of nitric acid. The powder of the undecomposed adamantine spar continued, as before, lying at the bottom, like an heavy fine sand. But when the mixture had begun to boil, I perceived an unexpected alteration. The powder swelled; rose from the bottom of the matrass towards the surface of the liquid, and changed its sandy appearance to that of a slocculent precipitate, nearly of the same form, with recently precipitated muriat of silver; but, on continuing the digestion, it again fell down in the form of an incoherent powder. This last acid likewise extracted a small portion of alumine; which I collected, after precipitating it by pot-ash.

The remaining powder of the adamantine spar, whose weight after ignition amounted to 74 grains, was treated in precisely the same manner as before, only with this difference, that I increased the proportion of caustic alkali, of which I now took a sextuple weight. After the mass had been ignited for sive hours, and refrigerated, it was found, as in every previous operation, to be very difficulty soluble in boiling water. At this time, by the addition of an acid to the filtered solution, a less quantity of loose earth, than before, was precipitated; but which even now was not siliceous earth. Boiling nitric acid likewise extracted from the residual powder a little aluminous earth.

When the adamantine powder, remaining after these repeated strong calcinations with alkali, was put on the balance, its weight was found to be 60 grains. It appeared now in the form of a fine, siliceous earth; and in order to examine it as such, I mingled it with one ounce of mild soda; upon which it was strongly calcined in a small silver-crucible, and at length urged to suston. The crucible was lest uncovered; because I intended to watch attentively, whether the blended mass would effervesce, during the action of the carbonated alkali, and thus betray a siliceous nature. The susson however, went on without the least frothing; and by this I was sufficiently convinced, that the earth under trial was not yet purely siliceous.

The melted mass proved, after refrigeration, to be as difficult of solution in water, as before. This alkaline lye, passed through the filter, shewed no appearance of having taken up any foreign substance. It remained perfectly clear and limpid, when saturated with acids; some few, hardly perceptible flocks, excepted.

I now endeavoured to feparate fomething from the refidue, again edulcorated, by means of strong sulphuric acid. Eight times its weight of this acid was accordingly poured upon it, and again with proper precaution distilled off from it to dryness. The residue, softened by hot water, was put on the filter, and the acid liquor, which passed through the paper, was saturated with pure vegetable alkali. Yet, even with this treatment, I only obtained a very slight indication of alumine.

On confidering this great obstinacy of the remainder left from the adamantine spar, which by the last operation hardly lost one grain of weight, I again recurred to the caustic mineral alkali. The powder, mixed with a tensold quantity of soda, was first ignited for sour hours; increasing afterwards the intensity of heat, until the mass entered into a thin sussion, in which state it was kept two hours. The silver-crucible would not longer resist the action of the fire; it was injured, though without detriment or loss of the mass, which was again with difficulty liquised in water, and then filtered.

The alkaline lixivium, thus obtained, deposited a tender earth, upon saturation with acids. But even this earth was not yet siliceous. It disappeared by a slight excess of the acid; and separated again, as soon as the point of saturation was restored, by the addition of alkali. When thus recovered, it was freed from adhering saline particles by washing, and added to the precipitates, obtained in the preceding operations.

Upon the remaining portion of adamantine spar in a pulverulent state, which in this process again had assumed an isabella-colour, I then assufed sour parts of nitric acid. The mixture thickened to a jelly; on which account I added sour parts more of nitric acid, and digested it in a boiling heat. The solution being diluted with water, and filtered, was saturated with salt of tartar; and the precipitate which it afforded, added to the preceding ones.

At this period, the quantity of adamantine spar, which had hitherto resisted decomposition, weighed 34 grains; which were mixed with 15 times their weight of caustic soda, and ignited in a brisk sire, during sive hours. Yet, notwithstanding this, the alkaline lye, procured from the re-dissolved mass, and saturated, deposited only a trisling quantity of a slocculent earth; and for this reason no diminution of weight was observable in the residue.

Digested with eight parts of nitric acid, the mixture again acquired a gelatinous confishence: and the acid, separated by filtering, likewise afforded only a scanty precipitate, on being saturated with alkali.

The powder, still undecomposed, weighed now 27 grains; which I blended again with 15 parts of caustic soda, and treated in the manner oftentimes stated. But I observed that the alkali, as well as the subsequent digestion in acids, extracted from it still less than before; since the remaining undecomposed part amounted yet to 24 grains.

I then refolved to try, whether perhaps a stronger degree of heat, than the silver-vessel was capable of bearing, might not give additional force to the action of the alkaline salt, and thus effect the farther decomposition of this stubborn residue. I therefore substituted an iron-crucible to that of silver. This residue, being mixed with four parts of mild pot-ash, and introduced into the iron-crucible, was exposed to a heat sufficiently intense to cause it to melt, and it was then kept for two hours in red susson. This obstinate body, however, could not be mastered. The liquor, separated from the dissolved mass, held no atom of earth in solution; but remained clear, when saturated with acids.

After the residue, lest on the filtering paper, had been freed by means of the muriatic acid from the particles of iron which it had acquired from the melting-vessel, and after it had been edulcorated and dried, I found it possessed of the same nature as before; and only one grain of its weight was wanting, which I suppose was not dissolved, but lost.

Having thus eleven times calcined and fused this stone, with alkali in various proportions, I at last gave up all hopes of conquering this residue, which at each operation proved

proved more and more refractory. And not expecting fucfess, even from repeating these tedious processes, that exhausted all patience, I turned my attention to the examination of the feveral precipitates that had been collected.—But I found that those which were obtained, by means of acids, from the folutions of the maffes calcined with alkali, were of nearly the fame nature as the precipitates, thrown down by alkalis from the acids, in which the adamantine spar was digested or extracted after every calcination. For this reason I mixed them all together, and chose the sulphuric acid, as the proper test for their examination. This menstruum, confisting of one part of the concentrated acid, diluted with four parts of water, immediately disfolved a confiderable part of the earthy precipitate; but another portion remained undiffolved, though the acid had been added to excess, and was affisted by a boiling heat. Upon this undiffolved earth, when separated by filtration, edulcorated, dried, and introduced into a retort, I poured four times its weight of concentrated fulphuric acid; and having again abstracted this last, by distillation, to dryness, in a fandbath, I foftened the refiduum with boiling water, placed it on the filter, and edulcorated the earth remaining on the paper. I found, however, that by this treatment, nothing of importance could be extracted from this earth; for the folution, faturated with alkali, yielded only one half grain of precipitated aluminous earth, which I re-diffolved in some drops of fulphuric acid, and added to the preceding folution

A small proportionate quantity of pure vegetable alkali being added to this solution, it was made to crystallize by repeated gentle evaporations; after which it shot into regular crystals of alum, which were collected.

I observed, however, that on every crystallization of this solution of alum, a white slimy earth was separated. E 3 I therefore collected it carefully, and treated it in the fame manner as the earth mentioned before: that is—I distilled from it four times its weight of strong sulphuric acid; softened the residuum in the retort with water; siltered the liquid which had distilled over, and saturated it with alkali. But hardly one half grain of earth fell down, and this was still aluminous. The earth which remained undissolved, exactly resembled that which has been mentioned before, and was accordingly added to it.

Thus I at length fo far fucceeded, as to decompose the adamantine spar into two different species of earth. But though the first evidently shewed itself to be aluminous, the nature of the second was doubtful. On supersicial consideration, this last might well be taken for filiceous earth; but its habitudes contradicted this supposition.

Encouraged by the hope of coming nearer to the discovery of its true nature, I repeated the operation so frequently noticed, of heating it to intense redness for some time, with fix parts of caustic soda in the filver-crucible, and increasing at last the strength of the fire so as to affect its thorough suffice. The melted mass had then acquired a striated crystallic texture. Yet the alkali took up but a small portion of it, as I sound by the weight of the undissolved earth, recovered from the calcined mass, after liquesying it by water. The residue, washed and dried asresh, was boiled for an hour with ten times its weight of strong nitric acid; from which, when separated again, and saturated with alkali, only an inconsiderable trace of alumine fell down.

I then faturated with nitric acid the alkaline folution obtained from the melted mass. It let fall a slight quantity of fine

a fine earth; not a particle of which was dissolved by nitric acid boiled upon it for some time.

This portion of earth, which was precipitated, and recovered by filtration, ought at last, agreeably to theory, to have assumed the character of pure siliceous earth. To make trial of it, I exposed it with soda to the action of the blow-pipe, in a quantity not exceeding three grains. But it did not prove to be siliceous; on the contrary, I found it to be of the same nature with the whole of the remaining earth, from which it was separated by the mineral alkali during the suspense.

However, in order to make a comparative experiment with real filiceous earth, I mingled a drachm of this last, precipitated from liquor of slints, with four drachms of caustic soda, and exposed them together, in a silver-crucible, to only a moderate ignition. Although this mass was hardly agglutinated by the operation; yet it easily afforded a clear solution in distilled water. And when this was saturated with an acid, the siliceous earth fell down, in its usual manner, in the form of a jelly-like substance, highly intumesced.

From all these processes it is sufficiently obvious, that the adamantine earth in no manner acts like the siliceous. If it were so, it should dissolve in fixed alkalis, by means of a red heat; more especially when caustic alkalis are employed, as was here the case: and it likewise should be recoverable from them by affusion of acids. But the earth, which after the first sufficiency, was thrown down by acids from the alkaline solutions, was not siliceous, but aluminous, which was immediately and entirely re-dissolved by adding more of acid. And in proportion as the alumine was separated from the mixture of the adamantine spar, by

alkalis as well as by acids, the unknown earth in question more and more resisted each solvent medium.

If filiceous earth, blended with equal parts, or with only one half of its weight of fixed alkali, be exposed to a melting heat, it unites with strong effervescence to the alkali, and affords a clear glas. And this result ensues both in the crucible, and before the blow-pipe, in small experiments. But this is not the case with the other earth. When brought before the blow-pipe in a small silver spoon, a little effervescence seems indeed to take place at the beginning of the fusion; but neither is the effervescence so strong, nor is there a clear vitreous globule formed, as in the first instance. Only a scorious mass, of difficult susion, remains.

A frit, composed of twenty grains of this earth, with as much carbonated soda, was exposed in a luted clay-crucible, to the strongest heat of the porcelain-surnace, which is so intense, that carrara-marble, or any other calcareous earth, if inclosed in a clay-crucible, melts without any addition, into a very hard, clear, and green glass. The refult of this experiment was, an opalescent, very hard, greenish-white glass; the fracture of which, however, exhibited signs of a texture, in divergent lines, radiated from a common centre at the bottom of the melted mass. Whereas siliceous earth, precipitated from the liquor of slints, when mingled with equal parts of soda, as was to be expected, yielded a clear glass in the same degree of heat.

What am I then to think of this earth? Shall I, perhaps, take it for a mixture as yet not totally decomposed, of two or more simple earths, perhaps the aluminous and siliceous?—This opinion is not without probable ground. The extreme obstinacy with which the adamantine-spar resists all attempts to decompose it, shews us the high de-

gree of attractive power, by which nature has most intimately mixed and united the constituent parts of this stone. Hence, in proportion as the aluminous earth was forced out and separated from the mixture of this stone, seemed the last residue, which, for a moment, I will suppose to be siliceous, to be more strongly attracted, and secured against farther solution, by its other remaining constituent parts, in the same manner, perhaps, as silver is defended by gold from the attack of nitric acid, when the first is united with the latter by sussion, in a proportion smaller than two to one.

But this analogy subsists only in appearance, and it might be applied only in the decomposition of the adamantine spar, by means of acids. For, in that case, the siliceous earth, because itself insoluble in acids, might protect the alumine which is most intimately combined with it; in the same way as gold, by its insolubility in nitric acid, preserves the silver against the action of the same acid, which in general so readily dissolves it. On the contrary, this example does not seem very applicable to the decomposition of this stone, in the dry way, by means of alkali; since, in this case, both earths, the alumine as well as the silex, are soluble in fixed alkalis.

Besides, the above conjecture is opposed by another circumstance. We are taught, by experience, that mixed bodies, whose constitutent parts are strongly attracted by each other, may certainly, for a long time, resist the force of solvents; but we also know, by experience, that, whenever the solution has actually taken place, especially when in the humid way, the reciprocal attractive power of the constituent parts is then either totally destroyed, or, at least, so far diminished, that nothing impedes their separation.

This is the ease with the earth of the adamantine spar: for it has actually been diffolved, conjunctively with the aluminous earth, partly in acids, partly in the alkaline lyes. And it has also been recovered, in the form of a precipitate, from both kinds of solvents.

What inference, therefore, remains?—This earthy sub-stance would not give any further indications of a mixture; and yet it presented none of the specific characteristic marks by which the other simple earths, at present known, are distinguished. Are we not, then, authorized to regard this body as a new, distinct, simple earth?—However, I do not venture, at this time, positively to decide on this point. Before this can be done, repeated experiments must throw more light on the nature of this earth. Yet, considering the scarcity of adamantine spar, and its discouraging resistence to chemical analysis, there is little hope for a speedy success.

It now remains, to state the proportion of the parts found in the adamantine spar. - The grains of magnetic iron diffeminated through it, constituted the fifth part of its whole weight; for when they had been separated, there remained 240 grains of the 300 employed. But this iron cannot be brought into the computation as a constituent part of the stone. Its proper constituent parts are, aluminous earth, and the above yet undetermined earth. After all the aluminous earth, collected in this analysis, had been diffolved in fulphuric acid, and properly crystallized, I obtained from it 2 ounces 6 drachms of alum, in regular crystals. As, therefore, the alumine contained in one ounce of this neutral falt, amounts, when ignited, to 56 grains, it is manifest, that those 2 ounces 6 drachms of crystallized alum contain 154 grains of aluminous earth, free from water.

The other yet undetermined earth weighed, after ignition, 53 grains. To these must be added the residue of 24 grains, which remained at last, on the decomposition of the stone, and was insoluble, and perfectly like the other portion. Hence this earth amounts, in the whole, to 77 grains; which, with the 154 grains of aluminous earth, give the sum of 231 grains.

### SECOND SECTION.

The circumflantial description of my first analytical attempt respecting the adamantine spar (communicated in the foregoing section), may serve as an example to shew the difficulties chemists have but too often to contend with, when examining unknown natural bodies. If the method of decomposing hard stones, pursued in my former enquiry, be compared with the process which will be explained in the present section, it will also appear from thence, how seemingly unimportant the causes often are which at one time ensure success to the undertaking, at another time render it difficult.

By the refults of the above experiments, I was induced to enquire, whether that earthy body, which was obtained besides the aluminous earth, did not deserve to be considered as a new, peculiar earth. However, I accompanied this conjecture with the express declaration, that I did not then mean to affert any thing certain; but, on the contrary, that farther experiments could alone decide that question. Nevertheless, I find this substance mentioned by several authors as an earth, the existence of which has been already proved, and named by them Earth of Adamantine Spar, Corundum-earth, &c.

On this account, I thought myself the more bound to make new researches on the adamantine spar, and to give, if possible, a complete decomposition of it, instead of the former preliminary and unfinished examination. Two reasons impose upon me this task; either to throw full light upon its nature if it should, on farther examination, prove to be really a distinct and new earth; or, if the contrary be the case, to prevent in time the spread of an error, occasioned against my intention.

The want of a fufficient additional quantity of this fosfil, which still continues to be scarce in Europe, has, however, retarded the execution of this purpose for a considerable time; but other experiments, conducted during that period, have made me acquainted with a shorter and more certain method of analysing gems, and other similar fosfil bodies, of difficult decomposition.

#### A.

# Decomposition of the Chinese Adamantine Spar.

- a) Hundred and fifty grains of hair-brown adamantine fpar, from China, containing interspersed particles of magnetic iron, were powdered by gentle blows in a mortar of polished steel, and the grains of iron extracted with the load-stone. The separated iron weighed 18 grains.
- b) Hundred grains of the powder from this stone were then weighed, and most finely levigated, moistening them with water, in a triturating-dish, made of slint. After desiccation the powder appeared of a grey colour, resembling that of wood-ashes, which passed into a brown-red, after gentle ignition. It now weighed IIO<sup>1</sup>/<sub>2</sub> grains, and consequently had received an increase of IO<sup>1</sup>/<sub>2</sub> grains of siliceous earth from the grinding-vessel.

- After this it was mixed in the filver-crucible with counces of caustic lixivium, prepared from the purest vegetable alkali, the saline contents of which lye amounted to one half of its weight; and after this the sluid was again evaporated, till the mass was dry. This done, the crucible was removed into the wind-furnace; applying at first a moderate heat, and increasing it gradually, until the crucible was red-hot; in which state it was kept for 3 hours.
- d) Upon the refrigerated mass, which had acquired a brown colour and considerable hardness, I repeatedly poured hot water, to soften it by degrees. The several washings being collected in one glass, there fell down a loose earth of a deep ochre-yellow tinge, which, when separated by filtration from the clear liquid, and dried in a gentle heat, weighed 58 grains.
- e) Muriatic acid threw down from this alkaline folution a copious precipitate, which was again wholly diffolved by a flight fuper-faturation with the acid. When decomposed by a boiling folution of carbonat of pot-ash, it produced a white loose earth, the quantity of which amounted, after gentle desiccation, to 201 grains.
- f) The above 58 grains of yellow earth (d) were covered with muriatic acid, and committed to digeftion. It diffolved in it to a yellow liquid, fomewhat turbid, which foon after formed a gelatinous coagulum. After being diluted with more water, and digefted, flirring it now and then, it deposited filiceous earth, which, when ignited, gave  $4\frac{1}{2}$  grains in weight.
- g) I then added mild vegetable alkali to the clear yellowish folution, separated from the siliceous earth by filtering. The brownish precipitate, which I thus obtained,

was fufficiently edulcorated, and, while yet moift, boiled with caustic lye. There remained a brown residuum, confisting of 15½ grains, after a gentle drying.

- b) These  $15\frac{x}{2}$  grains dissolved in the cold, in the muriatic acid poured upon them, and afforded a saffron-yellow solution, but which speedily congealed to a jelly. From this last, diluted in heat with water, there separated siliceous earth, whose weight, after ignition, was 3 grains.
- i) From the muriatic folution (b) I now precipitated, by caustic ammoniac, the iron which it contained. It fell down in brown-red flocks, and weighed  $7\frac{\pi}{2}$  grains, after being exposed to a red heat.
- k) From the alkaline folution (g), faturated to excess with muriatic acid, the addition of mild vegetable alkali precipitated, in a boiling heat, a white loose earth, which, being gently dried, weighed 29½ grains.
- l) Upon these  $20\frac{1}{2}$  grains of earth (k), added to the above 201 (e), dilute sulphuric acid was affused. When gently warmed, the earth was entirely dissolved; but when the solution had been concentrated by evaporation, it coagulated into an uniform clear jelly. This was again copiously diluted with water, in a warm temperature, and with repeated stirring; upon which siliceous earth separated, amounting, when dried and exposed to a red-heat, to 9 grains.
- m) The clear folution by fulphuric acid (1) was now combined with the requisite quantity of vegetable alkali, and by flow evaporation made to crystallize. It constantly yielded, until the end, regular crystals of alum. The

last remaining liquor, which confisted only of a few drops, I dried to a slimy consistence, which, upon dilution with water, still deposited ½ grain of filiceous earth.

- n) After all the crystals of alum, collected from the several liquors, had been re-dissolved in boiling water, I precipitated their earth by carbonat of pot-ash, washed, and dried it. But as the aluminous earth is much disposed, even after the most diligent edulcoration, firmly to retain a portion of the salts, that before were combined with it, more especially the vegetable alkali, whereby its own weight is necessarily increased; I took care to restore it in its true purity, by affusing upon it twelve times its weight of distilled vinegar, digesting it for several hours with this saluid; then adding as much caustic ammoniac as would saturate the acetic acid to excess; and lastly, by a perfect edulcoration of the precipitated alumine. When it was afterwards desiccated and ignited, its weight was found to be 84 grains.
- o) At last, the filiceous earth was put to trial. For this purpose I heated it to redness with four times its weight of mild vegetable alkali, and poured water on the mass which was obtained. It was completely dissolved, leaving only a slight portion of a slimy residue; and deposited again, during saturation with muriatic acid, the siliceous earth in its usual form.

Thus the decomposition of the adamantine spar was fully effected; and every uncertainty respecting the true nature of its constituent parts, that had remained after its first examination, is totally removed.

Hence, when we reflect that the magnetic iron, diffeminated in the Chinese adamantine spar, is merely to be confidered as a foreign substance mingled with it, and therefore cannot be considered as a constituent part, the following will be the constituent parts of adamantine sparatogether with their proportions in the bundred.

Alumine n)  Oxyd. of iron !)  Silex f)  b)  l)  m)	4 <sup>½</sup> / <sub>2</sub> 3 9	
From which subtract b)	17 10½	
There remain	6 <u>1</u>	. 6,50
	Lofs .	98
Tarib Carron Roya (Line Cyl.) A		100

B.

Decomposition of the Adamantine Spar from Bengal.

THE Bengal Adamantine Spar, or Corundum Stone, differs from the Chinese; first, in containing no interspersed magnetic iron, of which only now and then some sew grains adhere to its external surface; and, secondly, in this, that the ferruginous part, belonging to its chemical mixture, is less considerable. For this reason the whitish grey colour of

of that stone is brighter, its thin lamellas more transparent, and, as it appears, the hardness of the stone is in some degree greater.

a) When pounded in the steel-mortar, it afforded a white powder, inclining to pearl-grey. One hundred grains of it, triturated with water in the slint-mortar, I found, after drying and ignition, to have increased II grains in weight.

lown a maniney of dimy earth, which was entirely

- b) Upon these 100 grains, sour ounces of caustic lixivium, containing one half its weight of caustic alkali, were affused in the silver crucible; and the sluid evaporated to dryness. The mass being then ignited for three hours, with the necessary precaution, it was again softened by drenching it with water, and afterwards filtered. There remained a grey-white residue, weighing 47 grains when dry.
- c) The alkaline fluid (b) let fall, during faturation with muriatic acid, a copious, white, and loofe earth; which was immediately re-diffolved by a flight excels of the acid.

relials of alum, or fulpitat of alumine.

- d) The above-mentioned 47 grains of earth (b) completely diffolved in the muriatic acid. When this folution was mixed with caustic ammoniac, it afforded a slimy and very puffy precipitate. Mild ammoniac was then added to the liquor, which had been immediately separated from this precipitate by filtering, but it produced no farther precipitation.
- e) I then put into caustic lye the slimy precipitate (d), moist as it was, and digested them together. The mixture assumed the appearance of a thickish solution of gumarabic. On adding more caustic lye, the whole was dis-

folved into a limpid liquor, except some brown flocks, which, in the dry state, confissed of  $2\frac{1}{4}$  grains.

- f) Muriatic acid being affused upon this flocculent precipitate (e), a small portion of filiceous earth separated, and caustic ammoniac precipitated from the clear solution an exyd of iron, weighing, after ignition, 1½ grain.
- g) From the alkaline folution (e), the muriatic acid threw down a quantity of slimy earth, which was entirely rediffolved by a small over-proportion of that acid.
- b) Both the folutions (g) and (c), were next united and precipitated by carbonated pot-ash in a boiling-heat, and the dried precipitate was again dissolved in dilute sulphuric acid. When this solution, after the addition of a sufficient quantity of vegetable alkali, had been evaporated to the point of crystallization, it readily afforded clear and regular crystals of alum, or sulphat of alumine.
- i) The remaining part of the folution in fulphuric acid (b) thickened spontaneously to a clear jelly, on subfequent evaporation. This gelatinous matter, after being digested with an abundant quantity of water, and repeatedly agitated, again liquested by degrees. Upon this, some siliceous earth subsided; which, when separated by means of a filter, dried up in a raised temperature, in the form of transparent shining grains. It was levigated, together with the foregoing (f), and once more boiled with sulphuric acid. When dried again, and subjected to a red-heat, its weight amounted to 15½ grains.
- t) The above folution in fulphuric acid (i), was then evaporated for further crystallization. It continued to the end to yield successively regularly crystallized sulphat of

alumine: but the very last portion was still contaminated with filiceous earth, amounting to I grain after ignition.

1) All these several portions of alum were dissolved in water, and precipitated in a boiling heat by carbonat of pot-ash: and when the earthy precipitate which they asforded had been depurated by means of acetic acid, as explained in the preceding section, they gave  $89\frac{1}{2}$  grains of ignited aluminous earth.

Therefore, the products obtained by the decomposition of the Adamantine Spar from Bengal consist of

Alumine . Oxyd of iron Silex .		1) f) i) k)	15½ L		89,50
	Subtract		16 ½ 11	d le	
	Remain		5½ ·		5,50
	mashw z po notsi sali pilo		Lofs	and a	96,25 3,75
				a dipa	100

The very predominant proportion of the aluminous over the filiceous earth, exhibited by this decomposition of both varieties of the adamantine spar, affords a new proof, that alumine is susceptible of a greater cohesive power than silex is possessed of. Hence nature may form stones of extreme hardness almost entirely from aluminous earth; of which my lysis of the Sapphire will give, in the sequel, a very striking instance. On the contrary, it is evident that this does not hold good with respect to the siliceous earth, as appears from rock-crystal, its purest form; for, how inserior is this last in hardness to the sapphire, as well as to the adamantine spar!

On analyting the Chinese adamantine spar, we find that it was siliceous earth that remained, when muriatic acid was poured upon that portion, which was not dissolved by the alkali during ignition: But, on analyting the Bengal diamond-spar, this earth did not appear before the solution of the aluminous earth in sulphuric acid was prepared for crystallizing by evaporation; and at that period this acid caused it to coagulate into an uniform, colourless, gelatinous substance. This last circumstance is frequently attended by a phenomenon which seldom occurs, and is quite different from those which we usually observe on the efflorescing of salts. It is, that the mass, when coagulated to a clear jelly, branches out in several places, and forms separate, unconnected sigures, often in the shape of sour, sive, and six, sided longish pyramids, and often merely as conical points.

Similar phenomena take place, whenever the aluminous earth has entered into intimate union with a small portion of the siliceous, as will be seen by the following experiment:—I mixed 2 drachms of liquor of slints, the siliceous earth of which amounted to 10 grains, with 2 ounces of a solution of alumine in caustic lye; and saturated the mixture with muriatic acid. The earth, thus precipitated, again dissolved into a limpid liquor, on the affusion of a small excess of acid. When a second time precipitated by carbonat of pot-ash, and dried, it weighed 70 grains. I then poured upon it dilute sulphuric acid, and sound it entirely dissolved, without depositing the siliceous earth with

with which it was combined. After being in some degree evaporated, part of the solution shot into separate crystals of alum; and the remaining part coagulated in the form of a clear jelly, on the surface of which, after some days, crystalline pyramids sprouted out. And when I had afterwards digested this jelly with a large quantity of water, the siliceous earth subsided; and, being washed and ignited, it weighed again very nearly 10 grains.

However, this jelly, which is frequently colourless, and is formed by a folution of sulphat of alumine, in intimate chemical combination with finely dissolved siliceous earth, and gently evaporated, should not be confounded with the coagulum, which always takes place whenever the solution of aluminous earth in sulphuric acid has not been blended with the quantity of pot-ash requisite to the formation of perfect crystals. This last forms an opake mass, of a soliated texture, and soft, greasy consistence.

It yet remained to enquire into the causes which rendered my first analysis of the adamantine spar so very difficult. That one day is improved by another, is a truth which any attentive chemist has often had opportunity to experience in a very conspicuous manner. The method of preparing hard species of stones, recommended by Marggraf, Bergmann, and others, in order to weaken the cohesion of their parts, confifts in igniting them, mingled with a mild fixed alkali. But when I observed, that this way of preparing them would not answer the purpose in most of the stones belonging to the class of gems; and when I confidered that, in the strict sense, it was only the portion of alkalis free from carbonic acid, which is active in this operation, I tried to substitute caustic alkalis to the carbonated, and found that, by their affiftance, I attained my end with greater facility and certainty. The application caustic alkalis, in the dry state, is, nevertheless, attended with several inconveniences. One, and not the least of them, is, that by triturating them with the body to be subjected to analysis, no very accurate mixture will be obtained. Another circumstance, which embarrassed my first analysis of the adamantine spar, is, that in every attempt I subjected it to ignition in a brisk sire, with the view of ascertaining immediately the quantity of any portion which remained undissolved, or which was precipitated from its solution. But in this way the stone was rendered progressively more incapable of farther solution; and not only its solubility, in so far as it had been promoted by ignition with alkali, but also the advantage obtained in lessening the cohesive force of its constituent parts, have been again lost.

How greatly the decomposition of the harder gems is promoted by the use of caustic fixed alkalis in the liquid state, combined with the other requisite methods of treatment, may be proved by the second analysis of both the Chinese and Bengal adamantine spars.

IV.

### EXAMINATION

OF THE

### ORIENTAL SAPPHIRE.

It seems to be yet doubtful, whether the modern sapphire be the same gem which the ancients have denoted by this name. For we do not perceive in our sapphire the disseminated golden points, mentioned by them as one of its essential characteristic marks; whence Theophrasus\* calls it χευσοπασος, and Epiphanius+, χευσοσιγής. It is, however, certain, from a passage of Pliny, that the ancients did not understand by it the χυανος, or lapis lazuli, which usually contains interspersed speckles of a golden lustre; but they have well distinguished both species of stones. Inest ei (Cyano) aliquando et aureus pulvis, non qualis in sapphirinis. Sapphirus enim et aureis punctis collucet. Plinius, libr. 39. c. 9.

The gem that we call fapphire; is remarkable by its blue colour, which is so very pleasing to the eye, by its extreme hardness, and the high brilliancy which it shews when polished. Its specific gravity I have found to be 3,950, in those

<sup>\*</sup> de Lapidibus.

<sup>†</sup> de XII. gemmis, quæ erant in veste Aaronis,

T For the fake of the less informed, I add, (perhaps not quite superfluously) that the fossil, which is fold by Dutch druggists

those specimens, which were the subject of the following analysis, and consisted of clear, longish-round, abraded grains, of a pure azure colour.

According to the statement of the constituent parts of the sapphire hitherto given, and grounded on Bergmann's analysis, an hundred parts of it are said to contain:

35 Silex
58 Alumine.
5 Lime.
2 Iron.

But the following analysis, begun and ended with the greatest possible accuracy and precaution, will shew that the above statement was very incorrect.

- a) Hundred grains of fapphire, previously pounded to a moderately fine powder in a polished steel mortar, were most finely triturated with water in a grinding-dish of slint. When this sapphirine powder had been dried, carefully collected, and ignited, I observed, that its weight had increased 12½ grains from the siliceous earth of the grinding vessel.
- b) Two ounces of muriatic acid were poured upon these 112½ grains in a phial so as to cover them, and the whole was repeatedly digested with a moderate heat. The filtered acid, mixed with the edulcorating water, was then

faturated,

for fapphire, in the shape of small, heavy, black-grey, and internally resplendent grains, and which, since the belief in the medicinal virtues of gems, has lost ground, is now kept in the shops merely as an useless drug, is nothing else but magnetic octahedral iron, which in Ceylon accompanies the sapphire, hyacinth, and other gemmeous strata, and, together with those stones, is collected by washing off the sand.

faturated, in a boiling heat, with mild alkali prepared from tartar, by which there feparated yellow flocks, weigling two grains when dry. These being again dissolved in muriatic acid, and precipitated by caustic ammoniac, I transferred the precipitate, while yet moist, into boiling caustic lixivium. It deposited oxyded iron, which, after ignition, weighed balf a grain. The aluminous earth, taken up by the caustic lye, was again separated from it, and sound to weigh one grain.

- c) After this extraction by muriatic acid, as much cauftic lye was affused on the sapphirine powder, placed in the silver crucible, as was necessary to make the caustic alkali, contained in it, amount to six times the weight of the powder. It was next evaporated in a sand-heat, till the mass was dry; upon which the crucible was placed in the furnace, surrounded with charcoal, and subjected to a red heat for two hours. The contents of the crucible returned from the fire in the form of a whitish, loose, and friable mass.
- d) This mass was softened with hot water, and put on the filter. There remained a bluish-grey, slimy residue, which, being dried, gave a powder of little cohesion, weighing 34½ grains. On adding muriatic acid, it readily dissolved; but congealed soon after to a turbid jelly. By dilution with water, and digestion, some earthy particles were deposited, which, after washing and drying, amounted to 14 grains.
- e) When these flocculent particles had been removed, the muriatic solution was saturated with caustic ammoniac; and the result was an intumesced, transparent precipitate, which, being previously edulcorated, was digested, while yet moist, in caustic lye. It readily dissolved in it; with

the exception of a few brown flocks, which, when collected and ignited, weighed one fourth of a grain, and were exyd of iron.

- f) The alkaline folution (e) was decomposed by muriatic acid; and the precipitate which it afforded re-diffolved by a slight excess of that acid. Upon this, the earth was again precipitated by mild vegetable alkali, in a boiling heat. The weight of the earth obtained in this part of the process was 16 grains, after it had been washed and dried.
- g) In the same manner I combined with muriatic acid the preceding alkaline solution (d), obtained by softening the ignited mass. There resulted from it a copious white precipitate; but which was again totally dissolved, by a slight over-saturation with muriatic acid. The earth was then precipitated as fresh by mild vegetable alkali, assisted by a boiling heat; and was sound to weigh 280 grains, when washed and desiccated.
- b) To this earth I added the above 16 grains (f), as also the one grain of (b); and poured upon the whole dilute sulphuric acid. The solution, which was easily brought about in a moderate temperature, again deposited eight grains on cooling.
- i) These eight grains, together with the 14 of (a), being then mixed with fix times its quantity of caustic lye, were inspissated, and heated to redness. The mass, thus obtained, and afterwards liquested in water, lest, on filtering, a grey residue, weighing 17 grains after desiccation, which soon were dissolved by the affusion of sulphuric acid, leaving some sew, inconsiderable particles behind. The alkaline solution, when saturated with muriatic acid, continued

at first limpid; but it deposited four grains of siliceous earth, when evaporated in a warm temperature.

- k) I now mixed the folutions in fulphuric acid; mentioned at (b) and (i); added to them a proportional quantity of carbonated pot-afh, and, by gentle evaporation, caused them to shoot into crystals. At first, sine, pure, and regular crystals of sulphated alumine were formed: but the remaining liquor, while further evaporating, congealed into a clear, gelatinous matter, without any diminution of its transparency. Having poured upon it a quantity of water, I subjected it to continued digestion, stirring it now and then. By this management I effected the thorough separation of the finely divided siliceous earth, which was the cause of the coagulation; insomuch, that I was enabled to collect it on a filter. This siliceous earth, carefully collected, together with the above four grains (i), weighed 11<sup>2</sup>/<sub>4</sub> grains.
- 1) The remaining fulphuric folution, freed from its filiceous contents, was now fet to crystallize. However, the last portions of alum indicated, by their lemon-yellow tinge, that they still contained some metallic substance. In confequence of this, I re-dissolved them in water, together with the few residual drops of their mother-liquor, and combined them with prussiat of pot-ash (blood-lye). A blue precipitate subsided; but in so small a quantity, that the portion of iron, thus separated, could hardly be estimated at one fourth of a grain. The supernatant sluid, freed from it, afforded pure sulphat of alumine to the last drop.
- m) The crystals of alum, obtained in the several foregoing operations, being dried on a porcelain saucer in open air, amounted in the whole to 856 grains. They were then dissolved in boiling water, decomposed by carbonat of

pot-ash in the heat of ebullition, and the precipitated earth was edulcorated and dried. But, in order to free this earth perfectly from those saline particles, which still adhered obstinately, and augmented its weight, I subjected it to gentle digestion, with six ounces of distilled vinegar. Which done, I neutralized the acetic acid by caustic ammoniac; edulcorated asress the aluminous earth, then precipitated, and lastly, exposed it to a brisk red-heat, after drying. It weighed now  $98\frac{1}{2}$  grains.

n) It still remained to examine the edulcorating water. Being evaporated to dryness, and the residue re-dissolved in little water, there remained a slight portion of grey earth, which, when examined by sulphuric acid, proved to be calcareous. The solution yielded, during evaporation, selenitic crystals; which, when carefully collected, weighed 1½ grain, the calcareous earth of which should be estimated at one half grain.

What principally demands our confideration, in the refult of this analysis, is the remarkable and unexpected circumstance of the total absence of the siliceous earth, from among the constituent parts of the sapphire. For the 11½ grains of silex which were obtained (k), must undoubtedly be ascribed merely to the slinty triturating vessel, from which the sapphire had, on grinding, abraded 12½ grains (a), and at the same time had united with it so intimately, that I could not recover it without great difficulty, and even not without a small loss of three sourchs of a grain.

Hence, the following alone can be reckoned among the constituent parts of the fapphire, procured by decomposition:

3 63		11	
Alumine			98,50
Oxyd of iron b	$\frac{1}{2}$		
· e	) $\cdot \cdot \cdot \frac{1}{4}$		. I,
1	) · · 章)	- 1 1 at 4	
Lime	1)	.1.,	, 0,50
			****
			100.

Since on analyfing fossils, even with the most cautious management, there is always some unavoidable loss, it is probable, that the present perfect agreement of the sum of these constituent parts, with the original weight of the sapphire employed, is merely accidental. And the reason of this agreement must be sought for, in the variable state of dryness, communicated to the aluminous earth by heating it to redness.

Whence, subtracting the unimportant, and perhaps only casual portion of calcareous earth, as well as the slight quantity of ferruginous matter, we find in the sapphire, the nature of which is now developed, nothing else than a simple aggregate of pure aluminous earth.

But, what a high degree of cohesive power, and most intimate chemical combination, must nature be able to command, in order to be capable of transforming such a common substance, as the aluminous earth, into a body, so eminently distinguished and ennobled, as we find the sapphire to be, by its hardness, density, brilliancy, and resistance to the actions of acids and fire, as well as to natural decay in the course of all-consuming time!—It is, therefore, not the identity, or precise sameness of the constituent parts alone, but also the peculiar nature of their chemical combination, which constitutes the metaphysical essence of the products formed from them by nature.

V

# EXAMINATION

OF THE

#### CAT'S-EYE.

THE species of precious stones, known by the name of Cat's-eyes, has received that denomination from its property of reslecting, in certain directions, a changeable whitish esfulgence, in which it resembles the eyes of a cat.

As this stone is still a rarity in Europe, the description of its external characters, met with in the latest introductions to Mineralogy, could only be taken from the polished specimens which are brought to us from Geylon. As I have in my collection rough cat's-eye from the coasts of Malabar, for which I am indebted to the kindness of Francis Greville, Esq. in London, and which, besides, is one of its more unusual varieties, I think the following addition to the descriptions of its external characters, already published, will not be useless.

The largest specimen consists in a fragment, notably quadrangular, of one inch in length, three-sourths of an inch in breadth, three-sourths ditto in height, and three and a half drachms in weight. Its cross-fracture exhibits a brown-red colour of various shades, a moderate greafy lustre,

lustre, and minute sharp-edged prominences. On the longitudinal fracture, its colour is lighter, its lustre stronger, and it reslects variegated yellowish rays of light; at the same time, that an imperfectly soliated texture, spreading in various directions, is perceivable. On two contiguous sides it still retains its natural surface, or crust, which is formed lengthways of convex, roundish striæ; and its colour, which was at first brown-red, has saded into a dull brownish-yellow. Its edges and small splinters alone are faintly transparent.

I found the specific gravity of this rough cat's eye to be 2,625; whereas that of the whitish, greenish, and yellowish specimens from Ceylon is 2,660.

In the Essay on the Habitudes of several Stones and Earths in strong Fire, I have already shewn that the cat's-eyes are persectly infusible in the strongest degree of heat produced in the porcelain-surnace; therefore I shall at present mention only the change which they undergo in a weaker sire. For this purpose I ignited to redness in a crucible some of the common polished cat's-eyes, of a greenish and greyish-white colour, and quenched them in cold water. I found them afterwards absolutely unaltered in form, hardness, and splendour; but they were rendered totally opake, and acquired an extremely sine marbled jasper-like appearance, variegated with brown, reddish, grey, and white spots.

#### A

a) Two hundred grains of finely levigated Cat's-eyes from Ceylon, were mingled with 400 grains of carbonat of foda (mild

(mild mineral alkali), and the blended mass was exposed in a filver-crucible to gentle ignition for four hours, but without urging the heat to suspend in the next place I softened the mass with water; saturated it to excess with muriatic acid; and suffered it to stand for some time in digestion. A considerable quantity of filiceous earth then separated, which was collected on the filter, washed, dried, and lastly exposed to a strong red-heat. In this state it weighed 189 grains.

- b) The muriatic folution, mixed with the edulcorating water, and concentrated by evaporation, was faturated while yet hot with carbonated foda; and I obtained a precipitate, which, when washed and dried, weighed 15 grains.
- c) These entirely dissolved, with effervescence, in the muriatic acid. Only a slight portion of siliceous earth remained, which after ignition amounted to one grain.
- d) After the grain of filiceous earth had been feparated, caustic ammoniac was added to the folution. A yellowish-white, slimy precipitate was thrown down; which being immediately feparated by filtration, washed, and afterwards distolved, while yet moist, by caustic lye, left behind an oxyd of iron, weighing one half grain, when washed and ignited.
- e) I then, by means of muriatic acid, separated the earth taken up by the caustic lye; but being re-dissolved by a slight excess of this acid, it was again precipitated by carbonat of soda. When edulcorated, and dissolved in sulphuric acid, it shot into crystals of alum. This sulphat of alumine was then dissolved in water, and its earth again precipitated.

precipitated by carbonat of foda. This alumine, when edulcorated, and ignited after deficcation, was found to weigh 3½ grains.

f) The liquor which remained, after the precipitation had been effected by caustic ammoniac (d), was then combined in a warm temperature with mild mineral alkali; by which treatment, calcareous earth subsided, which formed felenite (sulphat of lime) with sulphuric acid. The lime thus separated from this compound, and ignited, weighed three grains.

Since, therefore, 200 grains of these cat's-eyes afforded

Silex .	(a)			189	}.	 190
	6)			I	7	In Horiza
Alumine	· e)		•			. 31
Lime	· f)	.01.	131			. 3
Oxyd of ire						

197 grs.

it follows, that it contains in one hundred,

Silex .	11.	1931. 91	95	
Alumine			1,75	
Lime .	1	11.	1,50	
Oxyd of iron			0,25	
			(:	
		7 0	98,50	
		Loss	1,50	
4 1 1 1 1 1 1 1	of dis	W. Late	100	1

B a)

- a) Hundred grains of the crude red cat's-eye from Malabar, described as above, yielded a grey friable mass; after being finely pulverized, mingled with 300 grains of caustic pot-ash, and ignited, but without sustion, for an hour in the silver crucible. It soon dissolved in water, and formed a turbid liquor. Upon super-saturating it with muriatic acid, and subsequent digestion and filtration, there remained a dealicate, white siliceous earth, which, after washing and drying, amounted to 115 grains, but after half an hour's ignition weighed only 93 grains.
- b) The muriatic folution (a), mixed with the washings, and previously concentrated by evaporation, was then precipitated by carbonated pot-ash, in the heat of ebullition. The yellowish precipitate, which subsided, weighed 8½ grains after desiccation.
- c) These 8½ grains completely dissolved in muriatic acid. Caustic ammoniae threw down from this solution a slimy earth; which only partially dissolved in the caustic lixivium, with which it had been digested, and left five grains on the filter.
- d) When the earth, taken up by the caustic alkaline lye, had again been separated from it, and washed and ignited, its weight amounted to two grains. It also afforded erystals of alum, on being treated with sulphuric acid.
  - e) The above five grains (c), digefted with fulphuric acid, still deposited filiceous earth, which, having been exposed

posed to a red-heat, weighed 1½ grain. The solution, freed from this earth, while evaporating, yielded felenite-crystals. The yellowish liquid, rinsed off from them with dilute or weak ardent spirit, and combined with prussiat of pot-ash, produced a deep blue precipitate; the quantity of which was so small, that the exyd of iron thus indicated, could not with propriety be estimated higher than at one fourth of a grain. Mild alkali still separated from the remaining liquor an inconsiderable portion of alumine.

f) Mild vegetable alkali, added at a raised temperature to the sluid, from which the caustic ammoniac separated the above-mentioned muddy precipitate (c), threw down another portion of earth, which united with sulphuric acid into sulphat of lime. The calcareous earth contained in this selenite, as also in that of (c), was reproduced, or separated from its accompanying acid, by boiling with a solution of mild alkali; and its quantity was sound, after ignition, to amount to 1½ grain.

According to this analysis, the constituent parts of this red variety of cat's-eye, consist in the bundred of

Silex .				a) c)	 9	$\frac{3}{1^{\frac{1}{2}}}$ .	94,50
Alumine							
Lime				f)			. 1,50
Oxyd of	iron			e)			. 0,25
			H		-	Lofs	98,25
							100

There-

## \$4 V. Examination of the Cat's-Eye.

Therefore, this proportion of the constituent parts, which in both varieties is to be considered as perfectly constant, together with their absolute infusibility, (not to mention the difference in the external character) afford sufficient reason for distinguishing cat's-eye from fel-spar, under which this sossil has been classed by several Mineralogists.—On the contrary, it would be more proper, in my opinion, to class it with the opals; among which also it was formerly reckal oned under the names of Pseudopal, Cat's-eye-opal.

VI.

#### ANALYSIS

OF

#### CHRYSOBERYL.

THE Chrysoberyl, found in the Brasil, passed for a variety of the Chrysolite, until M. Werner, Counsellor of the mines, was induced, by a more accurate comparison of their respective external characters, to separate the former from the latter; and to range it in the mineralogical system as a distinct species, with its present denomination. This Chrysoberyl, however, must not be mistaken for the Chrysoberyl of the ancients, which really was the substance indicated by this name; that is to say, the golden-yellow beryl; as may be concluded from its description, given by Pliny. Libr. XXXVII. Cap. V. Probatissimi sunt ex iis, (namely Beryllis), qui viriditatem puri maris imitantur. Proximi, qui vocantur Chrysoberylli, et sunt paulo pallidiores, sed in aureum colorem exeunte sulgore.

The modern chrysoberyl has hitherto been met with only in shivery, loose, rounded grains \*, of the size of smal-

<sup>\*</sup> Gefchiebe in German. Rachill by the miners; or fuch loofe, small, shivery stones, as most commonly lie on the top of the rock, or immediately under the vegetable earth. See Hooson's Miner's Distinary.—Transl.

ler and larger peas, of a pale-yellow colour, infenfibly verging to green. The furface of these grains, which is somewhat rough, strongly glitters, and usually restects variegated colours, like moonstone (adularia). But the fracture of chrysoberyl possesses a great splendour, which, in conjunction with a very considerable hardness, gives it a high brilliance when polished: and hence it may easily be consounded with the yellow diamond. Some few specimens exhibit some remaining traces of an originally crystalline figure.

The specific gravity of this stone I have found to be 3,710; which therefore agrees with that mentioned by Werner, from 3,698 to 3,719, and is precisely the mean between these two extremes.

The first analytical attempts upon it, which I made before I was acquainted with those skilful processes which I learned from later experiments, gave me a good deal of trouble, and at the same time destroyed a considerable part of my stock of these stones. But I pass them over, and confine myself merely to that analysis, the result of which was the complete decomposition of the chrysoberyl.

a) Hundred grains of chrysoberyl, previously reduced to a moderately fine powder, by pounding them in a mortar of polished steel, were levigated with water to perfect fineness in the slint grinding-dish. After the powder had become dry, I subjected it to gentle ignition, for the purpose of freeing it from all moisture. However, its weight was increased 13 grains.

b) Upon these 113 grains, introduced into a silver-crueible, I poured so much caustic lixivium, that the proportion

of alkali which it contained amounted to 800 grains, and evaporated the liquid again till the mass was dry. Upon this
I placed the crucible with its contents in a wind-furnace,
on a stand of porcelain clay, surrounding it with coals.
Attention was carefully paid to prevent the mass, which
greatly swelled in bulk, from flowing over the vessel. The
heat applied was at first rather low; but it was gradually urged
until the mass became red-hot. In this degree of heat it was
kept for two hours; but it did not enter into actual sussel.

- c) When this mass had cooled in some degree, I softened it in the crucible with water, and poured the solution upon the filter. When the sluid parts had passed through, there remained on the paper a loose, light-grey powder, which, when edulcorated and dried, weighed  $66\frac{1}{2}$  grains.
- d) The alkaline lye that had been separated, together with the edulcorating water, was first evaporated, to lessen its bulk, and then saturated with muriatic acid. An abundant white precipitate fell down, but was instantly and clearly re-dissolved, by a small excess of acid. Carbonat of pot-ash, added over a low fire, again precipitated this earth; which being washed, and dried in a gentle warmth, was loose, as white as snow, and weighed 138½ grains.
- e) The light-grey pulverulent refidue, mentioned at (c), amounting to  $66\frac{1}{2}$  grains, being digested with muriatic acid, left again a residue; which, after washing, drying, and ignition, weighed  $24\frac{1}{2}$  grains, and was found, upon farther examination, to be pure siliceous earth.
- f) This muriatic folution (e), separated from the filex, was next decomposed, in a boiling heat, by means of caustic ammoniac, and the yellowish precipitate, thus produced, was edulcorated; and, while yet moist, was boiled with

caustic lye. It entirely dissolved therein, some brown particles excepted. This residue was oxyd of iron, and weighed, after ignition in a gentle heat, 1½ grain.

- g) The alkaline folution (f) was faturated with muriatic acid. The refult of this process was a white precipitate, which, by a slight supersaturation, again formed a limpid solution. The earth was then a second time precipitated, by boiling with mild vegetable alkali. Its weight amounted, after desiccation, to 29 grains.
- b) These last 29 grains, together with the preceding 138½ grains of earth (d), to which I also added the two grains, which were collected from the edulcorating water by evaporation, were digested with diluted sulphuric acid. The whole was dissolved, excepting some said, which weighed 4 grains after ignition.
- i) When this folution, now perfectly clear, was a little evaporated at a low temperature, tender, spicular, or spear-shaped crystals, gradually separated from it; which I collected with proper care. They presented all the marks of selenite; and, on decomposition by a solution of carbonat of pot-ash, in boiling heat, they afforded 11 grains of mild calcareous earth (carbonat of lime). This calcareous constituent part of the chrysoberyl was, doubtless, before contained in the precipitate of (d); and, previous to it sfalling down, it was held in solution merely by the water, as it was then in the causic state.
- \*) This fulphuric folution I now combined with the proportion of carbonated pot-ash requisite to the formation of alum\*; which shot, by degrees, into regular crystals.

<sup>\*</sup> On the necessity of pot-ash, and its proportion in the formation of alum, see Hildebrands's paper in Nicholson's Journal, vol. IV. page 49.—Transl.

From

Towards the end, however, a flight portion of filiceous earth appeared, which, after ignition, was not more than  $2\frac{1}{2}$  grains. The weight of all the fulphat of alumine obtained amounted to 604 grains.

1) This alum was again re-diffolved in boiling water, and afterwards decomposed by means of carbonat of potash, at the heat of ebullition. After the precipitated earth had been washed, dried, and gently ignited, I digested it with distilled vinegar; which being neutralized by caustic ammoniac, the earth was again precipitated by this treatment, and again washed, desiccated, and heated to redness. It proved now to be perfectly pure aluminous earth, weighing 71½ grains.

We may, therefore, infer, that the constituent parts of the chrysoberyl, exhibited by this analysis, consist in the bundred, of

Alumine	1) .	. : .	71,50
Lime			6
Oxyd of iron			. 1,50
Silex	e) 24	$\frac{1}{2}$	
	b) 4		
The state of the s	k) 2	1/2	
and the same of the	-	-	
	31		
To be subtracted	a) 13	3	
Remain	. 18		18,00
		1 -	97
		Loss	3
		LX T	100

From comparing the present analysis of chrysoberyl with the following decomposition of chrysolite, it is evident how greatly their respective constituent parts differ, and confequently, how necessary it was to separate them from each other, in the systematical arrangement of the species of gens.

[ 91 ]

VII.

# EXAMINATION

OF

# CHRYSOLITE.

THE Chrysolite affords a fingular instance of change in names; since, at present, we call the same gem Topaz, which the ancients understood by the denomination Chrysolite; for it is evident, from the following words of Pliny, that the Topazius of the ancients is not our modern Topaz; but, on the contrary, the Chrysolite of the present times: Ejus tota similitudo ad porri succum dirigitur. Est autem am plissima gemmarum. Eadem sola nobilium limam sentit: catera Naxiis cotibus poliuntur. Haec et usu atteritur. Pliny Hist. Nat. Lib. XXXVII. Cap. VIII.—The cause of this change of name is so much the more unaccountable, as the denomination Chrysolithus (golden-stone) undoubtedly more applies to the Topaz, which is of a golden-yellow colour, than to our Chrysolite, which is green.

The more detailed external description of the Chrysolite, given by Werner\* with that degree of accuracy we are en-

<sup>\*</sup> Bergmännisches Journal, 3d year, 1790, Vol. 2, page 54.

titled to expect from such a master, comprehends all, that, in the present state of our knowledge, can be said on the natural history of that stone, respecting its external characters, and the marks by which it is to be dislinguished from the other species of stones, with which it has been so often confounded. But, on the other hand, an accurate chemical analysis, and hence also the knowledge of its proper place in the mineralogical system, have, till now, been so much the more wanting: a desiciency which I hope to remove, by now publishing the experiments to which I have subjected it.

To remove all doubts, I previously mention that the Chrysolites analysed by me, as well as those from which Werner has drawn up their external description, were bought by John Hawkins, Esq. in the Levant, on his travels for promoting the knowledge of Natural History, and were sent to me by him for that purpose.

The specific gravity of Chrysolites I have found to agree with the statement of Werner, namely, 3,340.

#### A

a) I took two hundred grains of rough chrysolite, and at first bruised them in the steel-mortar, and afterwards reduced them to a fine powder by trituration with water in the slint grinding-dish. This powder, when dried by heat, I observed had not increased in weight. I poured upon it two ounces of pure caustic lye, the alkaline contents of which amounted to one half of its weight, and evaporated the whole to dryness in the silver-crucible, and ignited

nited it afterwards for thirty minutes. There remained a friable mass, which, after cooling, was of a dusky olive-green.

VII.

- b) When this mass had been softened with water, the solution assumed the same colour, and a brown, undissolved portion fell to the bottom, of a slimy appearance. The solution being saturated to excess with muriatic acid, and sufficiently digested, acquired a saffron-yellow colour: upon which it was diluted with water, and siltered. A pure siliceous earth then remained, which, after ignition, amounted to 72½ grains.
- c) The muriatic folution, when decomposed in a boiling state by mild vegetable alkali, prepared from tartar, afforded an abundant, light-brown-red precipitate, which, upon deficcation, again entirely dissolved in muriatic acid, and by the affusion of caustic ammoniac, formed a brown-red precipitate; which was directly separated by filtering, then washed, and digested with caustic lye, while yet moist. However, only a small portion seemed to dissolve by this treatment.
- d) After the undiffolved matter had been separated from the alkaline solution (b), I super-saturated this last with muriatic acid, and added carbonated pot-ash, for the purpose of obtaining a precipitate. However, only a little earth separated, which, when collected, and tried for alumine by sulphuric acid, did not dissolve in it; but, on closer examination, proved to be siliceous earth, weighing  $3\frac{\pi}{2}$  grains after ignition.
- e) The brown precipitate, which had been digested with caustic lixivium (c), when dry and exposed to a red-heat, gave 38 grains in weight. It consisted of a pure oxyd of

iron. The whole was attracted by the magnet. Upon being diffolved in muriatic acid, and again precipitated by pruffiat of pot-ash, it yielded 88 grains of very deep-coloured Pruffian-blue.

f) The muriated fluid, after the ferruginous contents had been feparated from it by ammoniac (c), gave a copious white and loose earth, by adding carbonat of pot-ash. The mixture having been kept boiling for some time, this earth was separated by filtration, well washed, and dried. It amounted to 198 grains of carbonated magnesia (mild magnesian earth), which I divided into two parts. One half of it was strongly ignited for the space of an hour, and lest  $39\frac{1}{2}$  grains, which produced a brisk ebullition upon the affusion of sulphuric acid. The other half was introduced into dilute sulphuric acid. It directly afforded a clear solution, and pure sulphat of magnesia (Epsom salt), by crystallization.

Note. It was by mere accident that, on the precipitation at  $(\epsilon)$  no more ammoniac had been added than was just necessary to feparate the oxyd of iron; since otherwise, in all cases, the magnesian earth is also precipitated by ammoniac.

According to this decomposition, the constituent parts of the chrysolite should be in the hundred,

Ignited Silex . b) $36\frac{1}{4}$ d) $1\frac{3}{4}$	38
Ignited Oxyd of Iron e)	39,50
	96,50
Lofs	3,50
	100

B.

For a fecond analysis of chrysolite I chose polished specimens, which, besides a pure transparency, possessed also a brighter colour: whereas the crude chrysolites, employed in the foregoing process, were in some parts inclining to brown. As I intended, at the same time, to learn whether acids alone were capable of decomposing this stone, without previous treatment with alkali, I made use of the sulphuric acid, according to the manner in which Marggraf has employed it for decomposing the serpentine.

- a) I poured ten drachms of concentrated sulphuric acid, mixed with double that quantity of water, upon two hundred grains of most finely-powdered chrysolite, placed in a retort, and abstracted again the fluid, in a moderate distilling heat, until the remainder in the retort appeared a dry mass. The liquor which came over, emitted a moderate sulphureous smell. When cold, I collected the mass from the retort, the upper part of which I cut off, and lixiviated it with boiling water. The solution exhibited a greenish-colour, but so faint as to be hardly perceptible.
- b) The undiffolved refidue was boiled a fecond time, in a matrass, with two drachms of concentrated sulphuric acid, and two ounces of water. After this it was again collected on the filter, washed with an abundance of boiling water, desiccated, and heated to redness. It proved to be pure, white siliceous earth, weighing 78 grains.
- c) Both the fulphuric folutions (a) and (b) were evaporated to dryness in a porcelain-saucer. The residual mass had a greenish-grey tinge: it was sirst gently heated

in a porcelain pot, during which operation it emitted strong fumes; and after this it was thoroughly ignited in a brisk fire for the space of one hour.

- d) The ignited mass had then acquired a brick-red colour. It was levigated, lixiviated with hot water, and the red oxyd of iron, which it contained, was separated by filtration, and subjected to ignition. This oxyd weighed 39 grains: but as, in the present state, it was combined with a greater quantity of oxygen than when forming a constituent part of the chrysolite, in order to free it from that excess, it was immersed in melted wax, in a small crucible; and, after the wax had been burnt off, the oxyd was kept for some time longer in a low red-heat, the vessel being then covered. Its red colour had now changed into a blackish brown; it was also readily attracted by the magnet, and weiged 38 grains.
- e) After the colourless sulphated solution (d) had been evaporated for crystallization, it yielded, to the last drop, pure sulphat of magnesia. This neutral salt being disfolved, and decomposed in the heat of ebullition by carbonated pot-ash, afforded 213 grains of white and loose magnesian earth, the weight of which, after an hour's ignition, was only 87 grains.

From this fecond analysis, which exceeds the foregoing in the accuracy of its results, it appears that the constituent parts of chrysolite, proportioned to each other in the hundred, are as follows:

profit internal					101,50
Ignited Oxyd of Iron	•	d)		-	19
Silex		b)	٠		39
Ignited Magnesia .	10	(2)			43,50

Note,

Note. The reason why, in the present decomposition, there is a slight excess of weight in the sum of the constituent parts, instead of the usual loss in most other cases, undoubtedly depends in the variable degrees of dryness which those ingredients acquire on ignition.

In the quarries near Leutschau, in Hungary, we meet with a pale-green ferpentine, mixed with grey, and croffed by tender veins of asbestus. It also contains, copiously diffeminated, resplendent grains, of a high green colour, which, in some parts of my specimen, exhibit a rhomboid crystallization. Born \* and Fichtel +, who have given a more circumstantial information respecting this stone, call these grains Chrysolite. Fichtel, however, is uncertain whether they should not rather be considered as Chrysoprase. But this conjecture is too little favoured by the external characteristic marks; while, on the other hand, the minuteness of these grains, and the impossibility of separating them from the stone, which serves them for a matrix, will not admit of a chemical examination. Notwithstanding this, their presence in the serpentine affords a geognostic argument for confidering them as chryfolite, fince the conflituent parts of each have been discovered to be the same.

\* \*

A loose stony matter (rachill), which is found near Moldauthein, in Bohemia, has likewise, for some time past, been held out to be chrysolite: but, on judging from the

<sup>\*</sup> Catal. meth. et raison, de la collect. des Foss. Tom. I. p. 69.

<sup>+</sup> Mineralog. Bemerk. v. d. Karpathen, I. Th. Wien. 1791, page 60. 61.

fpecimens, rough and polifhed, which I have feen at *Prague*, I cannot confider them as fuch; because the external appearance of the rough pieces, and especially the fine airbubbles observable in the polished specimens, are rather an indication of a volcanic product. Herein I also find the opinion of *Lindacker\** to agree with mine.

<sup>\*</sup> See his Beitrag zur Geschichte der böhmischen Chrysolithe: in den Saml. physikal. Aussätze besonders die böhm. Naturge-schichte betreffend. 2 Band Dresden, 1792.

[ 99]

VIII.

# EXAMINATION

OF

# OLIVIN.

To the various stones which were formerly confidered as a subordinate species, or rather variety of chrysolite, also belongs the fossil known by the name of Basaltic, or Volcanic Chrysolite.

On giving the external description of this stone, together with that of the true chrysolite, Werner has not only accompanied it with the most instructive observations, but likewise, from his orystognostic inquiries, he has shewn the necessity of distinguishing the basaltic from true chrysolite. Whence also he considers the former as a distinct species, with the name Olivin, taken from its colour.

As it is the office of Chemistry to assist the Oryctognostic Science\* in the further improvement of its system, by

<sup>\*</sup> By Oryctognofy, Werner understands the scientific knowledge or discrimination of sossilis from each other, considered as simple, that is, not compounded aggregates of various different minerals; and their scientific arrangement, or classification, into a regular system, according to certain orders, classes, genera, species, varieties, &c.—Transl.

communicating certain facts relative to the conflituent parts of minerals, it is for the Chemist to examine whether, and how far, the conjectures respecting the essential ingredients in any fossil, inferred from its external properties, are founded in nature: and, consequently, to determine with what propriety it had obtained the place previously given to it in the system, on account of those supposed constituent parts.

For this reason I have thought it expedient to join the analysis of the Olivin with that of Chrysolite.

# FIRST SECTION.

Analysis of the Olivin; from Unkel.

To discover the constituent parts of Olivin, I first chose that from the Basalt of Unkelstein; in which rock it occurs in its perfect and undecayed state, in pretty large clusters, of a thoroughly equal, pale leek-green colour, and without any admixture of extraneous matters. Its specific gravity was 3,265.

#### A

a) Two hundred grains of finely pulverized Olivin were covered with two ounces of caustic lye, the alkaline part of which constituted half its weight. After the liquid had been evaporated, the dry mass was ignited for half an hour.

It affumed a grey colour, and was then liquefied or foftened with water, and filtered.

- b) Upon faturation with muriatic acid, the alkaline lixivium let fall a white earth, which, being collected and dried, was boiled with fulphuric acid. But this earth did not impart any foreign tafte to the acid; and when this last had again been decanted off, and saturated with mild alkali, it continued clear. Therefore the above earth was of the pure filiceous kind. When ignited, it weighed 49 grains.
- c) The aff-grey residue, separated from the alkaline lye (a), coagulated to a thickish brown mass, upon the affusion of muriatic acid. After this coagulum had been diluted and digested with sufficient water, there remained a copious, light, slimy, and brown residue, which, upon desiccation, weighed 152 grains.
- d) The muriatic folution, feparated from this refidue by filtration, was colourlefs. By the addition of mild alkali, prepared from tartar, it was decomposed with the affishance of boiling heat, and 181 grains of a very white, loose earth, were precipitated.
- e) When the brown refidue, mentioned at (c), after trituration, was digested with muriatic acid, it dissolved into a yellow liquid, leaving, at last, filiceous earth behind, weighing 43 grains after ignition.
- Note. It was undoubtedly this filiceous earth, fill intimately united with the ferruginous part of the stone, which in (c) prevented the muriatic acid from exerting its action on the oxyd of iron: yet this circumstance, at the same time, furnished the means of exhibiting, free from iron, that portion of the earth which the acid had dissolved.

- f) The ferruginous portion of the yellow muriatic folution (e) I precipitated by caustic ammoniac. It was then collected and washed; and, while yet moist, boiled with caustic lye. The lixivium was then again separated by siltration, combined with muriatic acid to super-saturation, and afterwards precipitated by carbonated alkali. Only a small portion of earth fell down, which, upon trial, proved to be siliceous, and weighed 4 grains, after it had been exposed to a red-heat. The liquor remaining, after the precipitation of the iron, was mixed with carbonat of pot-ash; but no surther precipitation nor turbidness ensued.
- g) The oxyd of iron, that was again collected after the boiling with muriatic acid (f), was put into melted wax, in a small crucible, and heated to redness; after this last had been burned off, it obeyed the magnet, and amounted to 25 grains.
- b) Upon the above 181 grains of earth (d) I poured dilute fulphuric acid; in which it diffolved with effervef-cence. When the folution had been reduced within a smaller compass by evaporation, it deposited minute spicular crystals, consisting of  $1\frac{1}{2}$  grain of selenite, the pure calcareous earth of which is to be estimated at  $\frac{1}{2}$  grain.
- i) The folution, on further evaporation, yielded pure fulphat of magnefia; which, being re-diffolved, and precipitated at the temperature of boiling, by carbonat of potash, deposited a very pure and loose magnesian earth, whose we ght, after ignition for an hour, amounted to 74 grains.

It follows, from these operations, that the constituent parts of the Olivin from Unkel are, in the bundred,

Ignited Silex	b) e) f)	$24\frac{1}{2}$ $21\frac{1}{2}$ $2$	-		48
Magnesia .					37
Ignited Oxyd of Iron .					12,50
The ball of the last		1	Lofs		97,75 2,25
				17	100

B.

With the view of confirming these results, I undertook another decomposition of the same Olivin from Unkel. In this instance I treated it immediately with sulphuric acid, in the same manner as I did with the chrysolite, without previous ignition, in conjunction with alkali.

a) I put two hundred grains of most finely pulverized olivin in a retort, pouring upon them ten drachms of sulphuric acid, together with a sufficient quantity of water; and again distilled the liquid over to dryness. Upon this I softened the remaining grey-white mass with hot water, and boiled asresh the undissolved earth, separated from the sluid, with 2 drachms of sulphuric acid, and sufficient water. The liquid, siltered off from the residue there left, was added to the first solution. What remained was mere siliceous earth, whose weight, after ignition, amounted exactly to 100 grains.

- b) The fulphuric folution (a) left, upon evaporation, a greyish-olive-green saline mass, which I evaporated still farther in a porcelain-crucible, urging it at last to a red-heat in a stronger fire. The mass retained at first its whitish colour, but at length it affumed a pulverulent state, and turned brick-red. When triturated, drenched with hot water, and filtered, it left a red oxyd of iron, which, after being treated with wax and ignited, weighed 24 grains.
- c) After the clear folution of (b) had been evaporated in order to crystallize, it shot wholly into sulphat of magnesia: but, when it was re-diffolved in a moderate proportion of water, some crystals of sulphated lime appeared, the quantity of which indicated one half grain of pure calcareous earth. These last having been separated, the remaining solution was decomposed, by means of carbonated pot-ash, in boiling heat. The magnefian earth, thus obtained, was pure, white, and loofe. When deficcated at a somewhat raised temperature, its weight amounted to 1881 grains; but it was reduced to only 77 grains, by ignition for the space of an hour.

By this method of analyfing, which, with regard to magnessan stones, is not only the most commodious, but also indicates the refults with the greatest exactness, the constituent parts of the Olivin from Unkel were found to be, in the hundred, as follows:

				100.75	
Lime	. c)	T.W.	J	0,25	
Magnesia					
Oxyd of Iron	. b)			12	
Silex	. a)	-		50	

Note. The same observation applies to the agreement of this sum with the weight of the substance employed, and the slight excess, as has been already mentioned, at the end of the second analysis of chrysolite.

# SECOND SECTION.

Analysis of the Olivin from Karlsberg.

THE Olivin from the Basalt of Unkel, employed in the foregoing examination, was, as has been mentioned, in its fresh and unimpaired state: but as most olivins shew more or less evident marks of decay, it still remained to enquire, whether, in those species of olivin that are more disposed to decay, any difference existed in their constituent parts. For this investigation I chose the olivin from the Basalts of the Karlsberg, near Cassel, in Hessia. I comminuted it coarfely, and washed off with water the yellow iron-ochre that invested its surface and its chinks. It then consisted, for the most part, of smaller grains of a faint greenishyellow colour, but in part also of larger grains, whose colour was a somewhat fresher leek-green. In these latter I observed black-grey particles, of a metallic lustre, imbedded in, or concreted with, their substance. When I had strongly ignited some of these upon charcoal, I sound that the green stony matter of the olivin had thereby become grey, dull, and opake; while the diffeminated black-grey particles had fuffered no change. This shewed, that they were not minute crystals of horn-blende, but iron, and especially of the nature of the specular, or grey iron-ore, because they were not attracted by the magnet.

- a) Upon three hundred grains of this olivin, finely pulverized, I poured 4 ounces of strong sulphuric acid, together with 2 ounces of water, and again distilled from it the sluid, which emitted a slight simell resembling sulphureous acid, until the residue became a dry mass. The sulceous earth, remaining after this mass had been boiled with water, was a second time boiled with half an ounce of sulphuric acid, and sufficient water. After this it was collected and ignited. It weighed 156 grains.
- b) In order to learn whether aluminous earth was one of the extracted conftituent parts, I took the third part of the whole of the fulphuric folution, and precipitated, by carbonated pot-ash, at the degree of ebullition, all that it held in folution. The fresh precipitate had a dirty, bluish colour; and I put it into caustic lixivium, as soon as it was edulcorated, digesting it with the lye for some time. The mixture was next diluted with more water; the lye, separated from it by filtering, was saturated with muriatic acid; and, after a slight super-saturation, again combined with alkali. But this produced neither a precipitate nor muddiness.
- c) Being thus convinced of the total absence of aluminous earth, I evaporated the remaining two-thirds of the sulphuric solution (b) to a dry saline mass, which I exposed to a strong red-heat in a crucible, for the purpose of decomposing the sulphat of iron which it contained. I then re-dissolved the ignited mass in water, and separated the red oxyd of iron by filtration; which, by ignition with wax, was rendered attractible by the magnet, and weighed, in that condition, 21½ grains.
- d) The folution, freed from the oxyd (e), crystallized by degrees into sulphat of magnesia. When this had again been dissolved in a small quantity of water, light, delicate, need-

needled crystals of selenite were left, the quantity of which hardly amounted to  $\frac{3}{4}$  of one grain, which indicates  $\frac{1}{4}$  grain of pure calcareous earth. To the dissolved sulphat of magnesia, corbonat of pot-ash was added in a boiling heat; and thus its magnesian earth was precipitated, amounting, after ignition, to  $75\frac{1}{2}$  grains.

Whence the conflituent parts of the Hessian olivin, and their reciprocal proportions in the ignited state, confist, in the bundred, of

Silex		u,n		a)		٠	52
							37,75
Oxyd	of I	ron		c)			10,75
							0,12

100,62

From these results, it is plain that the olivin and chryso-lite are very nearly related to each other; and, as the constituent parts of each other are so much the same, and their respective proportions not too diffimilar, it seems to me proper that these two stones should no longer be divided into two different species; but that the difference, deduced from their external characters, can only justify the subdividing them into two varieties of one species. Moreover, since no greater difference appears to take place between them, than, perhaps, that by which the basaltic horn-blende is distinguished from the common, it follows, that the olivin might be entitled to claim its former denomination of basaltic chrysolite.

According to the habitudes of the chrysolite and olivin in the heat of the porcelain-furnace, (mentioned in the first first Essay, n. 25, and 61-64), the former returned from the fire unaltered in form; but the second appeared in concreted grains, which were cemented together by the heat with more or less force of adhesion. From this circumstance I was induced to repeat the experiment with the chrysolite; with this difference, however, that I broke it into pieces of the fize of the grains of olivin, before I inclosed it in the charcoal. After those pieces had undergone the action of the fire, I found them, like ignited olivin, of an iron-black colour, opake, thinly glazed, and conglutinated. Yet both the glazing and concretion were somewhat less in degree than what took place in the Hessan and Greenland olivins.

[ 109 ]

IX.

# CHEMICAL EXAMINATION

OF VARIOUS

# SILVER-ORES\*.

AT the time when Philosophical Chemistry was yet in its infancy, and when it was not known how to decompose natural bodies otherwise than by fire, with very sew exceptions, the knowledge of the constituent parts of the bodies, belonging to the mineral kingdom, could not but be impersect. Chemists were satisfied with the products obtained in the dry way, as it is called, and either paid no attention at all to the other substances contained in these bonies, or, considing in groundless hypotheses, have fancied certain constituent parts, of which nothing could be discovered by the light kindled by Philosophical Chemistry, the basis of which is real facts.

Only, while this latter was advancing in its progress, the learned began to perceive, and seriously to attend to this great deficiency of knowledge respecting the fossil kingdom, as well as to the tottering foundation of the mineralo-

<sup>\*</sup> Read in the Royal Acad. of Scienc. at Berlin.—See the Collect. of Germ. Treatifes of that Acad. Berlin, 1793 and 1794.

gical fystems thereon established. Accordingly, this part of Natural Philosophy was enabled, by the laudable exertions of Schwab, Brand, Cronstadt, Wallerius, Marggraf, Scheele, Bergmann, and several chemists now living, to rise from obscurity; and chemical mineralogy has now obtained the place, which is due to it among her sister sciences.

Yet, all that has hitherto been done in this science, is nothing more than a splendid beginning. Our acquaintance with the constituent parts of soffils is still confined within narrow limits. Not only are we still ignorant of the composition of a multitude of soffils; but, even with respect to those, with which we appear to be already acquainted, further confirmation is required: for nothing is more detrimental to the progress of a science, than to adopt errors as undoubted and long-established truths; to transfer them from one system, and from one elementary treatise, into another, and to multiply them by conclusions which must be as groundless as the premises, from which they are inferred, are false.

If, therefore, a fystematical mineralogy, arranged according to the chemical constituent parts, (which, as yet, has hardly been established), is to be supported by a more solid foundation, and brought nearer to perfection, it is necessary that a long series of successive analytical experiments should be made. But since, for this purpose, a sound chemical knowledge, accompanied by patience, leisure, accuracy in management and observation, as well as a frequent sacrifice of scarce and costly sossils, are required; and since those circumstances do not usually coincide, this branch of natural science cannot hope for a speedy and plentiful harvest. It must still, therefore, as hitherto, only look for detached and occasional improvements.

Among

Among the numerous productions of the fossil kingdom, of which an exact chemical knowledge is yet wanting, the genus of the filver-ores seemed to me to require, in a high degree, a re-examination and amendment. For this reason I have subjected its chief species to analytical treatment; the results of which are communicated in the following sections.

# FIRST SECTION.

Native Hornfilver, or Corneous Silver-ore. (Horn-erz).

(Vitriolico-muriated Silver-ore, by Kirwan.)

THE Corneous is remarkable among the rarer ores of filver, not only from its richness, but also from the substance by which nature has mineralized that noble metal.

The name Hornerz appears to be of a later date than our knowledge of that ore, since several writers on metallurgy, of the 16th century, have already mentioned it with the appellation of Glaserz; for it is obvious, from the descriptions which those authors have given of it, that they did not mean our modern Glaserz, namely, the sulphurated silverore. Matthesius\*, noticing several of its varieties, calls them white, grey, yellow, green glaserz; and says, "it is transparent like horn in a lanthorn, and suffess in the flame of a candle."—Fabricius + mentions a liver-coloured silverore, "which in lumps, viewed against the light, is obscurely

<sup>\*</sup> Matthefius Sarept. 1585. Norimb.

<sup>†</sup> Fabricius de rebus metall. Zürch, 1566.

transparent like horn, and in small parts is entirely transparent like ice."—From this it may reasonably be conjectured, that the glaserz of the ancients has, in later times, been erroneously confounded with our modern one, as this denomination is, indeed, more suiting the hornerz, or corneous silver-ore, than silver, mineralized by sulphur; and, on the other hand, no reason can be found for giving that name to the latter.

During the 16th century, in which the Saxon and Bohemian mines yielded vast treasures, the revenues arising from this silver-ore often amounted to several hundred marks (8 ounces each): but, in the progress of time, it became scarcer and less known, until the celebrated Saxon master of the mines, Mr. Pabst of Ohain, discovered it, as it were, anew, and gave it the name Hornerz, because resembling the factitious horn-silver (muriat of silver.)

It occurred formerly at Joachimsthal, Annaberg, Schneeberg, Freiberg, and in greatest quantities at Johann-Georgenstadt. At present, it is also found in some mines of the Altaic mountains in Siberia; and, according to Sage, likewise in the province of Guamanga in Peru, together with the native silver.

With respect to external form, I have met with the following varieties of the corneous filver-ore.

1) Massive (Derbe). As such it has been worked, in the times of its abundance, in the above-mentioned Bohemian and Saxon mines, copiously, and sometimes in pieces of upwards of an hundred marks in weight. There may yet be seen, in the electoral-mineral cabinet, at Dresden, a piece of that kind, cut in a cubical form, weighing several pounds; and also a smaller

one, which has some impressions of stamps. Both these ores are probably remnants of that century, which have been fortunately saved. The colour of this corneous-ore is a dirty brown, though its proper hue seems to be the pearl-grey, and the brown tinge to arise from the interspersed iron-ochre. It is soft; and may, like wax, be cut with the knife into thin chips; is possessed of a waxen gloss, and transparent on the edges and thin places.

- 2) In lamellar pieces (schaalig), incumbent on meager quarz, in the form of a crust; from the Schlangenberge.
- 3) In still thinner layers, in part only incrusting, (angestogen, or lying superficially), at times accompanied by native gold, or also by lead-spar, or spathose lead-ores from the same place.
- 4) Crystallized in minute regular cubes, of a pearl-grey colour; from Johann-Georgenstadt.
- 5) In fine scales, or flakes, of a whitish colour. In this manner the corneous filver-ore, even now, sometimes occurs at fobann-Georgenstadt, upon brown iron-ochre Eisen bräune).
- 6) In an earthy form, mingled with argil. This is the genuine butter-milch filver (argillo-muriated filver-ore) of the former mineralogists, and which Veltheim\* has described. The specimen which I have seen was dug up in the year 1617, on the old St. George mountain, at Andreasberg, and is now preserved at Berlin, in the royal department of the

<sup>\*</sup> Crell's German edition of Kirwan's Mineralogy. Berlin, 1765, page 281, seqq. in the notes.

114

mines. It confifts of an actitic, kidney-formed nodule of calcareous spar, the cavity of which is filled with this butter-mileh filver, in the form of a deficeated earth, externally of a slate-blue, but of a brownish white on the recent fracture; with which ore, likewise, the outer sides of the specimen are for the most part coated.

7) In grey lime-stone, but imperceptible to the eye; from Annaberg, in Lower Austria. This last is the fossil mentioned by Justi\*, under the name of alkaline silver-ore.

\* \* \*

The following are the principal chemical refearches that have been made into the corneous filver-ore, as well as its effential ingredients, and are communicated to the scientistic public.

- I) That of Lommer +, master of the mines in Saxony, who has also given the best information respecting the history and external properties of this mineral. This author estimates the argentine portion of this ore, when in pure state, at 28 per cent.; but the violet-ore of this kind he supposes to contain also a portion of alkalized sulphur.
- 2) Woulfet is of opinion, that he has discovered, in the corneous filver-ore, besides the muriatic acid, the sulphuric, as a mineralizing medium. It is upon the authority of this statement of Woulfe that Kirwan, Bergmann, and other mineralogists, affert, that the silver is mineralized in the cor-

<sup>\*</sup> Justi, Chemische Schriften. I. Th.

<sup>†</sup> Abbandl. vom. Hornerz, von Lommer. Leipzig, 1776.

<sup>‡</sup> Experiments on the mixture of some minerals.

heous-ore by the fulphuric as well as by the muriatic acid.

- 3. Sage\*, of Paris, has examined the corneous filverore from Peru; and states the maximum contained of filver,
  in the hundred, to be from 70 to 74. He adds, that the
  metal is mineralized by muriatic acid; and, besides, combined with a peculiar fattish matter.
- 4) Laxmann +, of Petersburg, on the contrary, maintains, that no muriatic acid is contained either in the Siberian or Saxon corneous filver-ore; and that in it the metal is mineralized by fulphur, in the same manner as in the glaserz, viz. the vitreous or sulphurated filver-ore.

On confidering this discordance among the learned, respecting the nature of the substance which mineralizes the silver in the corneous-ore, I think that it will not be superfluous if, to the enquiries of these chemists, I add the experiments which I had the opportunity of making with several varieties of this filver-ore.

#### A.

The above-mentioned massive corneous silver-ore, from the larger specimen in the Electoral collection at Dresden, was the principal subject of my analysis, a sufficient quantity of it having been given me for that purpose with the greatest liberality.

<sup>\*</sup> Analyse Chim. et. concord. des trois regnes. Paris, 1786.

<sup>†</sup> Nov. Comment. Acad. Scient. Petrop. 1774.

- ) If the artificial horn-filver (muriat of filver), be melted by itself on the spoon before the blow-pipe, it soon and readily suses into a globule; and, when combined with mineral alkali, the filver is immediately reduced. But the native corneous silver-ore does not melt so easily; it rather runs into the consistence of pap, and at the same time separate metallic grains transude. Its reduction, by means of soda, is somewhat more difficult than that of the artificial horn-silver, and the reason of this difference depends on the portion of iron contained in this ore.
- b) Upon two hundred grains of the corneous filver-ore I poured three times their weight of pure nitric acid; but no action took place, either in the cold or in the heat of boiling; only a fubtle brown-red iron-ochre was feparated, which, being washed off from the remaining ore, and dried, amounted to 4 grains. Caustic ammoniac, added to the nitric acid employed, precipitated 5 grains more of iron. When it was afterwards mixed with muriatic acid, only a pale milky colour was produced, but no real corneous filver-ore deposited. It followed from this, that neither any free native filver, nor any portion of it mineralized by sulphur, had been contained in that ore. The horn-filver, after treatment with nitric acid, was reduced by twice its weight of falt of tartar, and yielded 133 grains of reguline filver.
- c) 1st. For the purpose of finding out, more accurately, its constituent parts, I mixed 200 grains with 600 grains of the purest alkali prepared from tartar, and brought the mixture into the state of susion in a glass retort, applying the necessary degree of heat. After refrigeration, I broke off the upper half of the retort, softened the suse, which was of a light-brown colour, with hot distilled water, siltered the whole, and edulcorated the residue.

2dly. This residue was then dissolved in nitric acid. The solution acquired a brown tinge, and the scum floating upon the liquor assumed the colour of bricks. When the argenteous parts were completely dissolved, there remained  $8\frac{1}{2}$  grains of a brown-red powder, which imparted a golden yellow colour to the aqua regia, with which it was digested, and left a white residue behind. This last consisted of horn-silver, mingled with a slight portion of the gangue, or matrix of the ore, and afforded, on reduction, 2 grains more of silver. Caustic ammoniae precipitated from the yellow solution 7 grains of oxyded iron.

3dly. The nitric folution of the filver was precipitated by common falt; and the muriat of filver thus obtained weighed, after reduction by means of foda, 134½ grains of reguline filver.

4thly. The fluid, left after the separation of the horn-filver, had a pale-yellow colour, owing to a portion of iron; which, precipitated by pure ammoniac, weighed 5 grains.

5thly After this, I proceeded to examine the faline mass, dissolved in distilled water, and separated from the silver, after the corneous-ore had been sufed with pure alkali (i). On saturating this mass with distilled vinegar, the solution was rendered turbid, and a loose white earth deposited, which, collected and dried, amounted to 3½ grains of argillaceous earth.

6thly. The argil being feparated, the folution was reduced to a dry falt by evaporation, and the alkohol, affused upon it, took up the acetite of pot-ash. The neutral salt, which was left behind by this process, and which consisted of the mineralizing muriatic acid and the alkali employed, I dis-

folved in water, and obtained from it, by repeated evaporation and crystallization, 117½ grains of muriat of pot-ash.

7thly. In order to learn whether and in what proportion Julphuric acid, which by fome writers has been mentioned as one of the conflituent parts of the corneous filver-ore, were really present in it, I again dissolved that falt in distilled water, and dropped into it liquid muriat of barytes. The mixture became turbid, exhibiting that appearance which indicates the prefence of only a flight quantity of fulphuric acid. I continued to add the barytes, until no more turbidness appeared. The weight of the precipitate thus obtained was 3 grains: but, as in these three grains of sulphated barytes the acid cannot properly be estimated to be more than half a grain, I think this quantity is too trifling to be confidered as one of the effential constituent parts of the corneous filver-ore. But if that half grain of fulphuric acid be estimated equal to 11 grain of sulphat of pot-ash, and be subtracted from the above 1172 grain of digestive falt, or muriat of pot-ash, there will remain of the latter only 116 grains, in which the concentrated muriatic acid amounts to 42 grains. Therefore,

# One hundred parts of this corneous-ore contain

Silver	*		67,75
Muriatic acid			21
Oxyd of iron			6
Argil			1,75
Sulphuric acid			0,25
			96,75

B.

I likewise examined the corneous filver-ore sound in the Schlangenberge. One hundred grains of it, mixed with 300 of soda, were sused in a small retort; and, after the saline contents of this mass had been dissolved in hot water, the remaining silver was dissolved in nitric acid. I then sully saturated with muriatic acid the aqueous alkaline solution, which contained the common or culinary salt, formed by the muriatic acid of that ore, and put it to the test with muriat of barytes. The portion of sulphat of barytes, thus genenerated, was as insignificant as that from the Saxon corneous-ore; so that also, in this case, the sulphuric acid may be considered only as an accidental constituent part.

To the nitric folution of the filver I added common falt; and thus I produced again the muriat of filver, which weighed 91½ grains, and afforded 68 grains of filver, reduced to the reguline state. What was wanting to make up the first hundred grains of the corneous-ore, consisted of ferruginous ochre and quarzose matrix.

Hence it is obvious, that the Siberian corneous filver-ore here examined, almost perfectly agrees with the preceding Saxon one in its exterior characters, as well as in the constituent parts.

#### C

The experiments made with the argillo-muriated filverore (butter-milch filver), described before (page 113), are the following:

a) Ignited by itself upon charcoal before the blow-pipe, it feebly conglutinated together, at the same time that mi-

nute globules of metallic filver were oozing through the mass. When fused with glass of borax, it dissolved into a clear, light-green, vitreous globule, and yielded a button of pure fine filver.

b) Upon 35 grains of that ore I poured nitric acid, and made it boil. Neither effervescence nor red vapours appeared; as, upon the whole, the acid seemed to attack it but weakly. The residuum assumed the form of a precipitate, resembling a cheesy coagulum. When the acid, then tinged of a faint blue, was separated through a filter, it admitted of combination with common salt, without being rendered turbid, or yielding any precipitate. By the addition of corbonat of ammoniac to excess, argillaceous earth was thrown down, and the liquor appeared of a rather deep blue. But, after it had been super-saturated with sulphuric acid, and iron immersed into it, it deposited a thin coppery crust.

The dried refidue weighed 30 grains. It was extracted by repeatedly pouring upon it caustic, or pure ammoniac, agitating it frequently. Nitric acid being added to a few drops of it, some horn-filver immediately precipitated. The whole of this solution, when evaporated by a gentle heat, dried up to crystalline slexible membranes of a pearl-grey, which tarnished into blue by exposure to air; and, when gently melted in a small silver-cup, ran into a waxy substance. The weight of this sused muriat of silver amounted to 10½ grains.

When the argil, that was left behind after the extraction of the horn-filver by ammoniac, was melted with foda, it still afforded a bead of filver of \( \frac{3}{4} \) of a grain. As this is equal to one grain of muriat of filver, the above 36 grains of this fosfil

fosfil contained 11½ grains of muriated, or  $8\frac{5}{8}$  of metallic filver, and  $2\frac{7}{8}$  grains of concentrated muriatic acid.

Hence one hundred parts of the argillo-muriated filver ore contain,

Silver					1.0		24,64
Muriatic acid						. 4.	8,28
Argil, withafli	ght	tra	ice	of c	opper		67,08
					*	*	-
							100

It is owing to the argil contained in this ore that it does not assume the same appearance when heated on charcoal as the common horn-filver, but that the metal transfudes in the reguline state in small globules; for as that earth deprives the muriated silver of its acid when heated, the silver is enabled to assume the metallic state. And it is on this account that the same phenomenon took place when I mingled artificial horn-silver with argillaceous earth, and subjected it to ignition upon a piece of, charcoal, with the assistance of the blow-pipe.

# D.

With the view of investigating the nature of the filverore, called alkaline by Justi, I dissolved one ounce of it in
pure nitric acid, and mixed the filtered solution with muriatic acid. It, indeed, turned somewhat opaline; but no
muriat of silver was separated by this process, nor
was there any reguline silver precipitated upon immersing into it a small lamina of copper. Finding, therefore, that the portion of silver contained in the lime-stone
could not be discovered in the nitric solution, I searched for
it in the brown muddy residue of the siltered solution. This
emit-

emitted an empyreumatic smell on being gently ignited, weighed afterwards 2 grains, and yielded with pure alkali a bead of fine silver. Hence it is probable, that in this fossil the silver is combined with muriatic acid; and, reckoning upon this result, the quantity of muriated silver which it seems to contain, may be estimated at from one and a half to two ounces in hundred pounds. Justi boasted of a method of extracting the silver from that mineral, known to himself alone; as, when treated by any of the usual processes, this metal could never be procured from it.

As filver, notwithstanding its great affinity with muriatic acid, enters into no combination with it while in the perfect reguline state; and fince that metal, as far as we know, is never found in the bowels of the earth in an oxyded state, it is difficult to afcertain the operation of nature in producing the corneous-ore. Bergmann\* was of opinion, that Woulfe had folved that doubt by afferting, that in the above-mentioned ore he had traced the fulphuric acid, befides the muriatic: for filver unites readily with fulphur; and, fince fulphurated filver not unfrequently undergoes a decomposition, more especially when, as in this case may be conjectured from the presence of ferruginous ochre, some pyrites disposed to difintegration intervenes, the fulphur passes over into the state of a free acid, and forms sulphat of filver. If now muriatic acid interferes, it will, by virtue of its greater affinity to filver, decompose the sulphat, and instead of it form corneous-ore.

<sup>\*</sup> Torb. Bergmann on the generation of natural corneous, or muriated metals. Grell's Chemische Annalen, 1784. Number 4, page 377.

Of that corneous filver-ore which is found in regular cubic crystals, Bergmann had already conjectured that it might be considered as pure, and free from all sulphuric acid. He also wished to convert this conjecture of his into an established truth, by duly examining that sossil; for, as he very justly says, it is better to sacrifice such a specimen, scarce as it yet is, to investigation, rather than to deprive the sciences of a means of enlarging our knowledge by preserving it.

The wish of the immortal Bergmann is in some degree accomplished, and his conjecture, for the most part, confirmed by the present enquiry; with the unimportant difference, however, that, instead of crystallized corneousore, I have employed a specimen of that which occurs in lumps, or massive.

In order to comprehend how nature can generate the corneous filver-ore, without the interpolition of fulphur or fulphuric acid, we may receive fome light from the following intelligence, taken from a letter of Proust, in Rozier's Journal de Physique. It is there stated, that the coined silver of the Spanish ship San Pedro d'Alcantara, that was wrecked on the coast of Portugal, became coated with a blackish crust of 48 of an inch thickness, during the short time before it was recovered from the sea. This crust broke off in scales, and was a true muriat of silver. Moreover, Pallas\* relates, that he has found on the Jaik, in Siberia, several old Tartarian silver coins, which in that tract of saline land were converted into true muriat of silver, some throughout their whole mass, and others on the surface only.

<sup>\*</sup> Nordische Beytraege, III. Vol.

From this knowledge of the conflituent parts of the corneous-ore, art is enabled to imitate nature pretty nearly. If muriat of filver be made to fuse uniformly at a moderate heat, an artificial corneous-ore is produced, which may be made more similar to the natural one by adding, before the fusion, a proportional quantity of iron-ochre. And if muriated silver be dissolved in caustic ammoniac, and the sluid evaporated in a gentle warmth, the horn-silver remains in small glittering scales, resembling those with which the native corneous-ore is found in part covered. But, if this solution be left to spontaneous exhalation in the air, the horn-silver will sometimes shoot into solid regular crystals, of the same appearance with the cubic crystals of the corneous-ore.

### SECOND SECTION.

# Red Silver-ore (Rothgültigerz).

THE principal character by which this beautiful genus of filver-ores is externally distinguished from others, consists in a peculiar red colour, on account of which it is subdivided into two species, the light, and the deep-red silver-ore. The colour of the first varies from a bright ruby to a garnet red; that of the second inclines more or less to a steel-grey, but the characteristic crimson tint is soon made to appear by scraping or rubbing the ore. The deep-red silver-ore is usually opake; the light-red, on the contrary, is in various degrees transparent.

With respect to external form, the red filver-ore is found massive, disseminated, investing or superficial, dendritic, and at times regularly crystallized. Its crystals usually possess the form of hexahedral columns, without any pointed

termination, or ending in trihedral or hexahedral pyramids. The light-red ore also occurs in fix-fided pyramids.

The denomination of Rothgültig, or Rothe gültiges Erz, given by the older German miners to this genus of filver-ores, was intended to fignify that it contained a portion of that noble metal, and thus to distinguish it from other ores, which resemble it in form and colour; but, with respect to their argenteous contents, are deaf (ungültig), or of no value; instances of which are afforded by the native red sulphuret of arsenic, red-blende, and garnet. In process of time, this appellation has degenerated into Rothgülden, by which the unexperienced might be missed to suspect in this ore some portion of gold.

Concerning its conflituent parts, it is the common opinion and doctrine, that the filver is mineralized in it by arsenic, as well as by sulphur. These three, silver, sulphur, and arsenic, are in all elementary books of mineralogy, and by all authors, flated as the conflituent parts of this ore, to which fome add only a portion of iron. Among those writers which, in chemical mineralogy, are reckoned claffical, Henckel feems to be the first who mentions arsenic as one of the chief conflituent parts of the red filver-ore, when he fays, " The high-red ore, besides silver, consists merely of arfenic; the deep-red contains sulphur also." After him, Wallerius introduces it by the name " Argentum arsenice et sulphure mineralisatum." Cronstedt adopts this statement, adding only fome ferruginous ingredient. Bergmann, likewise, is of the same opinion, in his Sciagraphia\*, calling it " Argentum cum arsenico sulphure

<sup>\*</sup> Torb. Bergmann, Sciagraphia regni mineralis. Lips. et Drefd. 1782, page 108.

mineralifatum:" and, in his differtation de Arsenico\*, he fays, "Arsenicum cum argento sulphurato mineram argenti rubram consicit:"—and at the same time he states their proportion to be, of silver 60, of arsenic 25, and of sulphur 13+. It was on the authority of these eminently learned men that all the other writers have received the abovementioned component principles of this ore as unquestionable sacts, and have transferred them into their works.

Yet, upon the whole, arfenic is not so general a mineralizer as has been hitherto supposed. Hence all the hypotheses grounded on its pretended presence, and according to which arfenic was confidered as a principle necessary to the generation or maturation of metals, especially filver, can no longer subsist. This supposition, which has never before been questioned, that most genera of silver-ores contain arsenic, has occasioned the prize question of the Royal Academy of Sciences at Berlin, 1773, "To what purpofes does Nature employ the arfenic contained in metallic ores? " Can it be proved, by experience, that it effectually serves to bring the metals to maturity? And if so, in what man-" ner, and how far is this effected?"-However truly Mr. Monnet, whose paper has been honoured with the prize, has demonstrated that arsenic has no essential share in the generation of metals, he might as well have deduced his demonstration in the shortest and most solid way, a priori from the non-existence of arfenic in the red and white filverores, and in the grey copper-ore (Fahlerz) abounding in filver-(for these the above Academy seems principally to have had in view on making their question)—had he convinced himself of the falsehood of the premises by a previous enquiry duly instituted.

<sup>\*</sup> Ejus'd. Opuscul. Phys. et Cham. Vol. II. page 298.

<sup>†</sup> Loc. cit. page 303.

It is probable the red-arfenic, which externally refembles the deep-red filver-ore, and, according to Henckel's testimony, used to be called unripe red filver-ore, has first suggested the idea of the presence of arsenic in those ores of filver.

After this digression, I now proceed to the chemical analysis itself. This, however, was particularly performed with the light-red silver-ore, of which I had an opportunity of selecting, for my repeated experiments, a sufficient number of fragments, pure and free from extraneous matter, from the mines of the Upper-barz, and those of Saxony.

#### A.

a) Upon five hundred grains of bright, crystalline, red filver-ore, from the pit Catharina Neufang, at Andreasberg, most finely pulverized, I poured fix times their quantity of a mixture of equal parts of nitric acid of 1,350 specif. grav. and distilled water. The phial was kept for several hours in a low digefting heat, fo that the agency of the acid could be but moderate. I then diluted the folution with water; caused it to boil; and, after the residuum had fubfided to the bottom, I decanted the clear folution. Upon the remaining pulverulent ore, a quantity of nitric acid and water, equal to the preceding, was again affused; and, in the same manner, proceeded with as at first. The ore appeared now to have been effectually decomposed: and for this reason the solutions, together with the refiduum, were put on the filter, and the latter properly washed.

b) The filtered nitric folution had no colour at all, having been very much diluted by the water by which the refidue

had been edulcorated. I subjected it to evaporation to one eighth part, and found the bottom of the evaporating glass-vessel, after cooling, covered with copious, finely-grained, tesplendent, and heavy crystals of a grey-white. To ascertain their nature, I procured, by a separate process, a quantity of a solution of the same red silver-ore, sufficient for this enquiry, and found that they were sulphat of silver. Being assured of this, I dissolved that sulphat by a proportionate quantity of water, assisted by heat, added it again to the nitric solution, and combined this last with muriatic acid, as long as any muriat of silver would precipitate; which, when collected, edulcorated, and dried, was sound to weigh 391½ grains.

- c) The fluid, from which the horn-filver had been thus feparated, was then reduced to a fmaller bulk, by distillation from a retort. This concentrated fluid became turbid, and left another grain of muriated filver on the filter. At this ime it contained no other foreign substance, except a confiderable portion of sulphuric acid.
- d) What remained undiffolved by the nitric acid, confifted of an ash-grey, pretty loose, or flocculent powder, of 202 grains in weight. When this had been gently digested for half an hour, with a mixture of 5 parts of muriatic acid, mixed with 1 part of the nitric, and then diluted with half its quantity of water, there remained, after filtering, careful edulcoration, and drying, 65 grains; which were the sulphureous contents of the ore. When this residue had been gently heated, the sulphur deslagrated, leaving 6½ grains of muriated silver behind. This sulphur, therefore, consisted of 58½ grains.
- e) After the filtered folution had been evaporated in part, it was poured into a large quantity of water. By this ma-

management, a white precipitate immediately enfued, which being separated by the filter, edulcorated, and dried, and laftly heated in a porcelain cup, gave 133 grains in weight. But I could not find the least trace of arfenic in it, though I had fubjected it to all the trials deemed proper for discovering its presence. On the contrary, it was manifest, that this precipitate wholly confifted of oxyd of antimony, quite of the same nature with that which is produced when muriatic folutions of antimony are precipitated by water. On exposing it to heat, a small portion of moisture still evaporated, attended with a muriatic fmell, which was hardly perceptible. When again put on a test, and mingled with a third part of charcoal dust, the coaly powder was flowly confumed, by burning, without any arfenical fmell, and left behind it the metallic oxyd, possessed of a grey colour, and partly blended, partly covered with a quantity of fine, grey-white, thining, acicular crystals, or the flowers of antimony, as they are called. But when it was fused in a covered crucible with tartar and powdered charcoal, it was completely revived into reguline antimony, which being blown off with the bellows, a bead of filver was left, weighing half a grain.

f) The liquor also, from which the antimonial oxyd was feparated, contained free sulphuric acid. On this account I put it into a retort, together with the nitric acid, from which the silver had been precipitated in the state of horn-silver, by means of muriatic acid, and continued the distillation until, at this temperature, nothing more would pass over; but, on raising the heat, thick white vapours had begun to rise. The sluid lest behind in the retort was found, upon trial, to be concentrated sulphuric acid. Upon diluting this last with water, and subsequent assume of muriated barytes, the sulphat of barytes from thence pro-

duced, amounted, after edulcoration and deficcation, to 194 grains.

Confequently, the conflituent parts discovered by these researches, are, filver, antimony, fulphur, and fulphuric acid. It remained yet to investigate, what are the proportions and the manner of combination of these principles, which constitute the red filver-ore.

First, concerning the quantity of filver contained in this one here examined, the muriat of filver (b) together with those portions that were left behind on the deflagration of the fulphur (d), and the concentration of the fluid from which the former had been separated (e), amounted, in the whole, to 399 grains. These being reduced, (including the one half grain obtained on driving off the antimony), yielded 300 grains of pure silver. This statement also perfectly agreed with the result of another experiment, which, by way of collateral proof, I performed in the dry way: for having, with this view, divided one docimastic centner of that ore into two parts, and carefully refined each of them on the cupel, inclosed in four times their weight of hammered lead, I recovered in each cupel a bead of fine silver of 30 pounds weight.

I endeavoured to ascertain, by the following counter-experiments, the metallic portion of the oxyd of antimony; which, after deducting, by guess, one grain for the half grain of silver which was contained in the ore, amounted to 132 grains. Upon one hundred grains of pure reguline antimony I poured four parts of muriatic acid; and, when warmed, I continued dropping nitric acid into this sluid, until all the metal was dissolved. After the solution had been concentrated by gentle evaporation, I added water to precipitate the dissolved metal. The precipitate thus obtained, after

lixiviating the faline parts, and deficcation, weighed 130 grains. Hence the above 132 grains are equal to 101½ grains of metallic antimony.

With regard to the fulphuric acid, it may be doubted, whether the acid here discovered, had really previously existed as fuch in the red filver-ore, forming, with the metal, fulphat of filver; or whether that acid ought not rather to be confidered as a product, arising from the oxygenation of the sulphur, while the ore was diffolving in nitric acid. But even the external properties of that ore, especially its transparence, and the absence of metallic lustre, will sufficiently prove, that the latter is not the case: for, with regard to the mineralization, ores may be conveniently divided into two classes. The first comprehends the true ores in the strict sense; that is, those only in which the metallic portion is either in the perfect, or very nearly perfect, reguline state, and whose mineralizer is fulphur. A metallic luftre, and absolute opacity, are effential properties of fulphurated ores of this kind. To the fecond class belong those ores, the metallic part of which is acidified by oxygen, either alone, or in combination with fulphur and acids. The exterior characters of the ores of this class are various. Some of them are transparent even to pellucidity; others, on the contrary, exhibit only an earthy appearance. But all these are particularly diffinguished from the genuine or true ores, by the total abfence of metallic splendour. Among the silver-ores, therefore, the vitreous filver-ore (glaserz), the black silver-ore (sprodglas-erz), and the white silver-ore, belong to the first class, or sulphurated ores; but the red, and the corneous filver-ore, belong to the fecond class, or ores mineralized by acid principles.

The peculiar manner in which the nitric acid exerts its diffolving power on the red filver-ore during the digeftion,

affords another argument to shew, that in this ore the portion of filver does not exist in its perfect metallic state, and mineralized by fulphur; but, on the contrary, is combined with oxygen, at least for the greater part; and hence, that it there exists in a calciform state. The nitric acid acts upon it much too weakly, to oxygenate the fulphur in any confiderable degree; in confequence of which, only a proportionally finall quantity of nitrous gas is produced in this folution. This fact is still more confirmed by the following experiment. Some finely pulverized red filver-ore, together with a large quantity of strong muriatic acid, were subjected to digestion for some hours, at a boiling heat. The acid, separated by filtration, was examined after cooling, and was found to contain, not only filver, and antimonial particles, but also sulphuric acid. Now, as muriatic acid alone is incapable of converting fulphur into a free or uncombined acid, it follows, that the fulphuric acid must already before have existed in that ore, in the capacity of an acid. Even Henckel, whose great merits in chemical mineralogy are at present almost totally disregarded, has already stated it as a certain fact, that the filver may be extracted from its red-ore, by muriatic acid alone, affifted by fuccessive digestions at the degree of boiling. It is also probable, that the fulphuric acid, prefent in that ore, contributes to the folubility of the metal in the muriatic acid.

The fulphuric acid, contained in the above 500 grains of the red filver-ore, produced 194 grains of fulphated barytes. Other comparative experiments proved to me that this acid amounted to  $85\frac{1}{2}$  grains of 1,850 specific gravity. But as this acid must be supposed to be combined in this ore with the filver in a concrete state, or freed from water, and not in the state of liquid sulphuric acid, I hope to come pretty near the mark, if, till a more accurate computation can be made,

made, I allow 40 grains for the sulphuric acid of that degree of concentration.

In order to ascertain whether any volatile parts, and of what kind, were discharged by the red silver-ore, when treated in fire with exclusion of air, one ounce of it, coarsely triturated, was placed in a small glass-retort, which, being connected with the pneumatic quicksilver-apparatus, I continued to heat till the ore was in sustion. However, nothing passed over into the jar filled with mercury, excepting that portion of atmospheric air, which was expelled from the retort by the heat. In the intermediate glass-balloon volatile sulphureous acid collected, in the form of fine drops of dew; in the neck of the retort there appeared a slight trace of sublimed yellow sulphur; but the ore in the retort did not lose so much as one entire grain of its weight.

These same experiments, made for the purpose of discovering the ingredients in the red silver-ore, I repeated with another specimen from the same mine; but, as the result of these last, excepting some unimportant deviations, agreed with the former, I am satisfied with the constituent parts resulting from the investigation of the above-mentioned 500 grains, and which are:

Silver	 Total o	300
Reguline antimony		101,5
Sulphur		
Concrete sulphuric acid		40
		son ors.

Therefore, one hundred parts of this red filver-ore, from Andreasberg, contain:

K 3

Silver

Silver :							60
	antimony						20,3
Concrete	Sulphuric	acio	d	9		•	8
							-
							100.

B.

The second species of the red silver-ore, which I have analysed, is the bright-red and crystalline, from Churprinz Friedrich August, near Freiberg. But, as I treated these in the same manner as the preceding, I shall confine myself to the results only; according to which, one hundred parts of this ore contain:

Silver			•	62
Sulphur				8,5
drajosnani-s ludo si				100.

This Saxon fossil, therefore, perfectly agrees with that from the Harz, with regard to its constituent parts, and likewise very nearly as to their proportions. The quantity of silver also was found to be the same, when the process was performed in the dry way; since 100 pounds of this ore, properly dressed or mingled with four times its weight of lead, and subjected to cupellation, likewise afforded 62 pounds of metallic silver.

In this Saxon red filver-ore, as in the foregoing, there was no veftige of arfenical matter to be found, although arfenic conflantly accompanies the ores dug out from that mine.

In the preceding analytical refearches, concerning the red filver-ore, I have indeed mentioned fulpbur, and fulphuric acid, as two particular products; yet I do not mean to fay by this, that they are two separate and really distinct constituent parts, actually existing in the ore. It is rather more probable, from the nature of the subject, to suppose, that in the undecompounded ore, both together constitute only one homogeneous ingredient part, and that the oxygen, by which the fulphuric acid was generated in this process, had before been uniformly diffused over the whole mass of the fulphur. But, if fo, there is no doubt, but that the red colour of the ore, which in general is erroneously ascribed to some arsenical matter, depends on that state of fulphur in its first degree of oxygenation, which by some is rightly called oxyd of fulphur. On this account, the filver, antimony, fulphur, and oxygen, are, in the strict sense, the genuine constituent parts of the red filver ore, taken in its natural state.

Laftly, I did not think it necessary to re-examine what Bergmann afferted, in his Essay de Arsenico, concerning the red silver-ore. He says—"Minera argenti rubra egregie aquâ forti decomponitur, argentum et arsenicum suscipiente, adeo, ut tandem solum sulphur in sundo restet." From this it might be inserred, that Bergmann had employed for this experiment a specimen of the red silver-ore, which had no antimony, but really some arsenic, among its constituent

parts; otherwise, by the established principles of chemistry, the antimoniacal part of the ore must of course, together with the fulphur, have remained behind as a metallic oxyd, infoluble in nitric acid. In order to fet this contradictory point in a proper light, I boiled five parts of strong nitric acid upon 100 grains of this red ore for some time; after which the mixture was diluted with water, and the folution filtered while yet warm. This extraction by strong nitric acid was fucceffively repeated, until only a fmall portion of fulphur remained. The folution procured by the first digestion, deposited, in the cold, granular sulphat of silver; but those of the succeeding digestions yielded also some particles of antimony, which subsided in delicate, light scales, of a filvery luftre. By this experience, therefore, I learn, that reguline antimony, instead of being corroded by nitric acid into an indiffoluble oxyd, makes an exception from that rule when in combination with fulphuric acid, as was here the case. And, for this reason, I found that a folution of this metal was effected, when, by way of a comparative trial with pure reguline antimony, I used a menstruum composed of strong sulphuric and nitric acids. This fact has already been mentioned by Wenzel\*. Upon this property of antimony, that its folubility in nitric acid is promoted by the fulphuric, is founded the rule that ought to be observed in performing processes on the red silver-ore; which is, that for the purpose of extracting its filver, weak nitric acid, and only a gentle digestion, should be employed.

<sup>\*</sup> See his Lehre von der Verwandtschaft der Koerpen. Dresden, 1777. page 182.

### THIRD SECTION.

Vitreous Silver-ore. (Silberglanzerz.)

THE appellation glasers, which the German miners have given to this richest fort of all filver-ores, is inconfistent with its real natural qualities, and can only have been retained from the antiquity of the term. Not only is the absolute opacity of this ore, but also its softness, and ductility, (on account of which it may be cut, hammered, and coined, as eafily as lead) are absolutely incompatible with the notion of glass. An instance of the last mentioned property is afforded by those medals, which were made of it under the reign King Augustus I. (of Poland,) and had the impression of his portrait. Henkel\* was therefore fully entitled to fay-" Glaserz is meant to signify the same as " glanzerz, which name it probably has received at those " mines, where no other ore, conftantly possessing lustre, was " to be found; and, in particular, it seems, that the miner who gave it first that name, happened to meet with a spe-" cies of glaserz of variegated colours." Supported by this authority, and still more so by the nature of that ore, I shall make use of the more suitable denomination, silberglanzerz.

That this species of ore is a mere fulphuret of silver, is too well known to need farther confirmation. Only the proportion of its constituent parts, as stated by mineralogical writers, appeared to me to require correction. This, upon Bergmann's † authority, is generally said to be 75 parts

<sup>\*</sup> Henkel redivivus. page 51. † Sciagr. reg. min. § 163.

of filver, and 25 of fulphur. The portion of the filver is rated much higher by Brünnich\*: namely, at 180 marks, or at ninety in the bundred. On the contrary, Sage + estimates the sulphur at 16 parts in the hundred of this ore, and consequently the silver at 84. By the following experiments it will be seen, that of these two, the opinion of Le Sage is the nearest to truth. That this more accurate statement was before known among the earlier authors in mineralogy is proved by these words of Lazarus Erker † 6 Thus

we may reckon among the filver ores of easy fusion, the

" most eminent of these, the glaserz, which is compact, of a lead colour, in quality nearly equal to native silver, and

co loses in the fire little more than one sixth part, all the

" rest being good pure silver, &c."

#### A.

a) One hundred grains of cubically crystallized vitreous filver-ore (from the mine Himmelsfürst, near Freiberg), previously cut into shreds, were digested, in a low heat, in eight times their weight of nitric acid, of 1,350 specif. grav. diluted with half its quantity of water. The activity of the acid proved to be but moderate, partly because, as the ore was not capable of being pulverized, on account of its softness and ductility, the shreds presented a considerably smaller surface to the acid. After the solution had

<sup>\*</sup> Cronstedt's Mineralogie, verm. d. Brunich. 1780. page 186.

<sup>†</sup> Analyse. Chim. et concord. de trois regnes. par M. Sage. Paris, 1776. Tom. III. page 250.

<sup>†</sup> Erker Probierkunst. Francsort, 1598. page 3.

been accomplished, the remaining brownish-yellow sulphur, when separated, washed, and dried, weighed 13 grains; but, on being burnt on a porcelain test, it left one grain and a half of fulphated filver, which, fufed with mineral alkali, gave a filver-button of one grain.

- b) The colourless nitrous solution, when combined with common falt, edulcorated, and highly deficcated in a warm temperature, yielded 122 grains of horn-filver, the metallic portion of which amounted to 84 grains. By this, including the above-mentioned one grain, the proportion of the filver contained in 100 parts of that ore is determined at 85.
- c) The fluid decanted from the muriat of filver, contained nothing but a small proportion of disengaged sulphuric acid. This, however, should not in this instance be confidered as a constituent part of the ore, but was undoubtedly formed during its long digeftion in nitric acid. Hence those 15 grains, which, after deducting the 85 of filver, remain to make up the 100 of the ore employed, may all be fafely put into our account, as its fulphureous part.

#### B.

Next, in order to examine the truth of the preceding refult, in the dry way, I took the vitreous filver-ore from Foachimsthal, in Bohemia. An hundred grains of it were divided into two parts, and each of them placed in a feparate affaying test, well dried beforehand under the muffle. Heat was then applied, at first moderate, to drive the ful-

phur

phur flowly off, and only towards the end its intenfity was increased to the requisite degree. The beads of filver obtained from each test, were of equal weight, and their sum amounted to  $84\frac{13}{16}$  grains.

In consequence of the approximation of this last result to that of the foregoing experiments, the constituent parts of pure, ductile, vitreous silver-ore, taken upon an average, are proved to be:

Silver									-0.0		1		85	
Sulphur		•	- •	*	0								15	
												con		ejąc:

### FOURTH SECTION.

Brittle Vitreous Silver-ore.

(Sprodes Silberglanzerz.)

That filver-ore, which occurs in the Saxon mines, with the name of fpröd-glaserz, and to which the röschgewächs, as it is called in Hungary, feems to belong, is distinguished, as to its external properties, from the species last mentioned, both by its darker colour, and by its brittleness, or want of ductility. Wallerius and others ascribe that friability to an admixture of arsenic; but without reason, since this property is owing to an antimonial ingredient.

For the subject of my present analysis, I selected the lamellated, friable, vitreous silver-ore, from the mine Alte Hossinung Gottes, at Grosswoigtbserg, near Freiberg, which is there found in thin tables, for the most part cellularly accumulated, of a black iron-colour, and is associated with a

fort

fort of calcareous spar, crystallized in low six-sided columns, with trihedral terminations, which is met with in the clefts of a rock of *Gneifs*.

- a) If ductile vitreous filver-ore be fused upon a piece of charcoal, by the affistance of the blow-pipe, its sulphur is quickly volatized, and a button of pure filver remains. But it is otherwise with the brittle ore: for the bead left after the evaporation of the sulphur is brittle, and cannot be purished by the addition of borax. However, if a little nitrat of pot-ash is added to the red-hot bead, it will destroy the portion of baser metal which it contains, and then the borat of soda causes it to yield a pure button of silver.
- b) One hundred grains of ore, previously levigated, were gently boiled in a sufficient quantity of nitric acid, diluted with an equal quantity of water. This operation was repeatedly performed, till the black colour of the powdered ore disappeared, and the insoluble portion had become of a loose texture, and had acquired a grey-yellow colour. When filtered and dried, this residue weighed 26 grains.
- c) On adding a folution of common falt to the above filtered folution, which had affumed a pale-greenish colour, a copious precipitate of horn-filver ensued, which, edulco-trated and dried, gave 88\frac{3}{4} grains. Four parts of this afforded three of filver, by fusion with soda.
- d) The remaining folution was next combined with fulphat of foda; but neither any turbidness, nor any indication of the presence of lead, appeared. Upon this, caustic ammoniac was affused to excess; and the grey precipitate, which then fell down, and which the volatile alkali could not again render soluble, weighed five grains. Urged by aeat, it melted into a consistence, like pap, at the same time

that a weak arfenical smell was perceived. After this precipitate had been once more diffolved in nitric acid, the addition of soda caused it to yield a whitish-yellow, alkaline sulphuret, a dirty brown, and Prussian alkali, a deep-blue precipitate, liable to the attraction of the load-stone, after ignition. Therefore, it consisted of iron, with a slight trace of arsenic.

- e) The proportion of copper, indicated by a blue colour, in confequence of the addition of ammoniac, and which still remained in the folution, was but slight. For, after the folution had been faturated with sulphuric acid, polished iron immersed in it, was invested with so slight a coppery crust, that no copper to any amount could be collected.
- f) Those 26 grains, which continued insoluble in the nitric acid (b), were digested in nitro-muriatic acid, till nothing appeared to remain but the mere fulphur. Its weight amounted to 13 grains; but, after deslagration, it left behind it about one grain of quarzose matter of the mine.
- g) From this it is obvious, that 13 grains, or one half of the above 26 grains, were held in folution by the nitromuriatic acid; and these were precipitated entirely in the form of a white powder, upon the affusion of 20 parts of water. When ignited, this precipitate assumed a yellowish colour; but there was nothing, either of arsenic, or any other volatile substance, perceivable. By combination with sold, it became reduced to pure reguline antimony; which, as such, admitted of being blown off without leaving any residue, in its usual form of a thick white smoke, adhering to the contiguous bodies in the form of needle-shaped flowers (oxyd) of antimony. Those 13 grains of oxyded antimony

mony are equivalent to ten grains of that metal in the regu-

One hundred grains, therefore, of this foliated, brittle, vitreous filver-ore, contain:

Silver	. ()	0 0		66,50
Reguline antimony	· g)			10
Iron	. d)			5
Sulphur				
Copper and arsenic	d) e)	about		0,50
Extraneous matter f	rom the	mine .		I

95.

Confidering the minute quantity of arfenic and copper, they can be reckoned only as cafual ingredients; and the fame holds good with respect to the quarzose matrix. But, as the antimony exists in that ore, intimately combined with the filver and sulphur, it must be considered as one of its essential constituent parts.

## FIFTH SECTION.

# White Silver-ore. (Weissgültigerz.)

NATURE has not confined herself to one certain determined law, in fixing the proportions that obtain among the constituent parts of the white filver-ore. This fact accounts for the difference of colour, lustre, and fracture, observed in the various specimens of this ore; which also, for the same reason, has been often consounded with the brittle vitreous silver-ore, the grey copper-ore, the compact plumose antimonial-ore (dichtes federerz), and the compact galena, or potter's

lead-ore (bleyschweif), &c. It is owing to this difference in the proportions of its component principles, that it is found, at one time, bright, and of a light grey; at another, of a lead-grey, and only glittering; of a fracture compact and even, fometimes finely grained, or even passing into the fibrous texture. Hitherto it has not been met with, except in lumps and disseminated.

Of its conflituent parts, few particulars have been given by former authors. Henkel\* feems to be the first who enumerates them:—"Weisfgültiges Erz," fays he, "is pro"perly a light, or bright-grey filver-ore, which yields 14
"marks of that metal, if it be perfectly pure and compact.
"It contains, besides, a little copper, arsenic, and sulphur,
"of which, however, it is difficult to ascertain the propor"tions." It is probably upon this authority of Henkel, that late writers unanimously suppose the essential ingredients of this ore to be silver, copper, arsenic, and sulphur; to which Cronstedt, Bergmann, Kirwan, and several others, add iron. Wallerius mentions two varieties of it: the one without, the other with iron. Lehman, on the contrary, supposes some lead instead of iron.

Yet, how little these supposed constituent parts agree with the real ones, will be manifest from the following experiments, made with the two principal species of the white filver-ore.

<sup>\*</sup> Henkel redivivus. Dresd. 1747. page 57.

#### A.

## Light white filver-ore.

- a) Among various minerals, dug in the mine Himmels-fürst, behind Erbisdorf, near Freyberg, I selected those that contain the bright white silver-ore in solid masses. From these, when pounded, I picked out a sufficient quantity of fragments, unmixed with the coarse-cubical galena, which accompanies this ore. It was easily levigated, and afforded a blackish powder, soliling the singers.
- b) Upon four bundred grains of this powder, I poured four ounces of nitric acid, of the strength before mentioned, and two ounces of water. After sufficient digestion in a gentle heat, the solution was decanted, and the residue again exposed to a warm temperature, with two ounces of that acid. This mixture I next diluted with eight parts of water, and continued to digest it for some time. I then separated the undissolved residue, consisting of a greyish-white powder, which, after washing and drying, weighed 326 grains.
- c) The folution, which was nearly colourless, was combined with common falt, by which a confiderable quantity of muriated filver was immediately produced. The next day were found over the horn-filver, which lay at the bottom of the vessel, tender needled crystals, which, upon closer examination, proved to be muriat of lead. On this account I boiled the whole precipitate in a large quantity of water, by means of which the muriated lead was re-diffolved, and separated from the muriat of filver, collected on

the filter. This last, when reduced by fusion with soda, yielded  $81\frac{1}{2}$  grains of reguline filver.

- d) What remained of the folition, together with the liquor obtained by the decoction of the horn-filver, I evaporated in part; and by adding a faturated folition of Glauber's falt, I obtained from it 45 grains of fulphat of lead, which, upon reduction, afforded 32 grains of lead in the metallic state.
- e) The remaining part of the folution I now faturated with pure ammoniac; upon which a light-brown precipitate fell down, weighing 40 grains, when edulcorated and ignited in a low heat. As that precipitate had the appearance of a mixture of iron and argil, I diffolved it again in nitric acid, and precipitated, first, the iron by means of Prussian alkali, and afterwards, by the addition of soda, a loose earth, which, when desiccated and ignited, weighed 28 grains, and, upon trial with sulphuric acid, was found to be aluminous earth. This, being subtracted from the above 40 grains, leaves 12 for the oxyd of iron, which may be estimated at nine grains of metallic iron.
- f) After this, the residue, that remained from the solution of the ore dissolved in nitric acid (b), was subjected to a closer examination. I attempted to decompose it by muriatic acid, repeatedly poured upon it, and in every instance digested over it in a heat of ebullition. The process was rendered somewhat difficult by the sine needled crystals, which were deposited from the solution as soon as the heat fell below the boiling point. Similar crystals likewise shot on the paper, through which the solution, though yet boiling, was siltered, and I gradually re-dissolved them again in warm muriatic acid. At last there remained 51 grains of sulphur, leaving, after designation upon a test, two

grains of a grey refidue, one of which diffolved in muriatic acid, and was added to the preceding folution. The other grain was *filiceous earth*. The true quantity of the fulphur, therefore, amounted to 49 grains.

- g) While the muriatic folution was cooling, it deposited a quantity of acicular crystals. These being separated, one half of the remaining fluid was distilled over in a small retort, and, from the folution thus concentrated, more cryftals, fimilar to the first, were deposited. This treatment was continued until no more crystals would form. When these crystals, collected together, were mingled with twice their weight of black flux, and reduced in an affay-crucible, thinly lined with charcoal-dust, they afforded 1603 grains of lead. This lead, subjected to cupellation, emitted, at the first application of heat, a few antimonial vapours; it then fined quietly, and left a button of filver, weighing \$ of a grain. This determines the proportion of lead at 1601 grains; from which, however, a trifling quaintity should be deducted for the portion of antimony before mentioned; though it could not be well determined, besides that it could not weigh much above half a grain.
- b) The fluid feparated from the muriat of lead, concentrated, and covered with a large quantity of water, deposited its metallic part, which, in the form of a fubtle, white powder, was only oxyded antimony, and being kneaded into a mass with soap, was reduced in a luted assaying-crucible, by means of black slux, into  $28\frac{1}{2}$  grains of pure reguline antimony. Some more small globules were found adhering to the lid of the vessel, of which I collected three grains; but still a small portion appeared to have escaped through the joinings, and for this reason, the true amount of antimony, which I obtained, may be reckoned at somewhat more than the  $31\frac{1}{2}$  grains.

Hence

Hence the product of the 400 grains of the light white filver-ore, here analysed, consisted of:

Silver .		. ()	100		811/2 7 6 - 5 - 200
T		g)			$\frac{81\frac{1}{2}}{\frac{1}{8}}$ 81 $\frac{5}{8}$ grs.
Lead .	100	od			$3^{2}_{160\frac{1}{4}}$ $3^{2}_{192\frac{1}{4}}$
Reguline	antimony	( b)		9	31½ grs.
Iron .	2000000	. e)	10		9
Sulphur		· f)			49
Alumine	. ,	. e)			28
Silex .		· f)			I
SULT- FIRM					
					3923 grs.

Which, in one hundred parts, makes:

Silver .		-			20,40	
Lead .						
Antimony						
Iron .					2,25	
Sulphur					12,25	
Alumine					7	
Silex .				4	0,25	
						Miler
					98,09	

With respect to the argillaceous earth, found in the mixture of this ore, it may be questioned: Whether it be merely adventitious, or one of its constituent parts. If, at the same time, there had been discovered in it a proportionate quantity of the siliceous earth, they might both together be taken for a clayey matter of the mine, accidentally intermingled with that ore. But, considering the wide difference in the proportion of one part of silex to 28

of argil, the latter appears to be one of its actual conftituent parts, though not effential.

## B. Andalules will Lorder lo

### Dark White Silver-ore.

- a) As of late this variety of the white filver-ore has but feldom occurred in pure masses in the Saxon mines, I facrificed to analysis a specimen, which was procured in the year 1720, from the pit Junger Himmelsfürst, at Freyberg, and consisted of a solid, very pure, white silver-ore, of an inch in thickness, that crossed lamellar galena.
- b) From two hundred grains of this pure ore, finely pulverized, I obtained a colourless solution by the affusion of three ounces of nitric acid, and an equal quantity of water. It was at first gently digested with the ore, then diluted with water, and, after a second digestion, strained through the filter. The silver, thus dissolved, was precipitated by means of common salt. The muriat of silver, thus produced, and dried in a warm temperature, amounted to 24% grains, which are equal to 18½ grains of reguline silver.
- c) Afterwards, on combining this folution of the ore with Glauber's falt, fulphat of lead was generated; the quantity of which, when edulcorated and dried, amounted to 93 grains, or to 66 grains of metallic lead.
- d) Liquid caustic ammoniac separated from the remaining study a brownish, loose precipitate, which, upon ignition, weighed  $6\frac{1}{2}$  grains, and, upon farther treatment, yielded  $4\frac{1}{2}$

L 3

grains of oxyded iron, (equal to  $3\frac{1}{2}$  grains of the regulino metal), and, besides, two grains of aluminous earth.

- e) By adding nitric acid, a greyish-white residue of 132½ grains was lest; which, when extracted with the necessary quantity of muriatic acid, lest another residue of 52 grains; of which, after its sulphureous parts had undergone a flow combustion, only eight grains remained. Hence the proportion of sulphur consisted of 44 grains.
- f) These eight grains, digested with muriatic acid, were dissolved by it, except  $1\frac{1}{2}$  grain of filiceous earth.
- g) All the preceding muriatic folutions were then fo far reduced by flow evaporation, as to form numerous crystals. After cooling, I caused the fluid which still remained to drain off from the crystals; any foreign matter, that might have adhered to them, I washed off with a mixture of one part of muriatic acid, and two of alkohol; and, after deficcation, I found their weight to be 22½ grains. They consisted of sulphat of lead, the metallic portion of which amounted to 16 grains.
- b) The liquor, separated from them, still contained the antimonial ingredient of this ore. By dilution with a sufficient quantity of water, a white oxyd of antimony was thrown down; whose weight, upon drying at an increased temperature, proved to be 56 grains, and for which 43 grains of reguline antimony must be allowed.

It appears, then, that the dark, dull white filver-ore contains in one hundred parts:

Silver b)	9,25
Lead c) and g)	
Reguline antimony b)	
Iron d)	
Sulphur e)	
Alumine d)	rinciples.
Silex f)	
helency being removed by the prefer analy	
Them are rede harmen to a state of the	

Consequently, this analysis of the above two varieties of the white filver-ore renders it evident, that it is neither arsenic, nor copper, but lead and antimony, which constitute the characteristic constituent parts of this species of metallic ore; and that the two last, for the future, should be mentioned as such.

Though these ores are usually accompanied by galena, the lead found in them should not, on this account, be considered as accidental; since it there exists in intimate mixture. It is a particular and remarkable phenomenon, and an anomaly in our knowledge of the elective attractions of bodies, that, even in the repeated digestions of the ore, neither the strong nor dilute nitric acid is capable to dissolve the whole of the admixed lead; and to destroy its combination with the antimonial ingredient.

Modern mineralogists have been induced, by the external and sensible differences of colour, lustre, and fracture, which exist between the above two varieties of the white silver-ore, to regard them as two distinct species, and have introduced the second into the systematical arrangement as the only genuine white silver-ore; separating from it the first, which is of a brighter hue, and has been ranked with the brittle vitreous silver-ore, treated of at Sect. IV.

But as the reason for this classification was merely sounded on some varieties of the external characteristic properties, it could only subsist as long as there was wanting a chemical investigation of these two varieties of the white silverore, as well as the chemical knowledge of their component principles, which depends on that enquiry.

This deficiency being removed by the present analytical processes, and it being demonstrated that the constituent parts of both are of the same nature, differing only in their proportions, they should be no longer described in systems of mineralogy as particular species, but only as varieties of one and the same species. For this reason, the folid, brittle, vitreous silver-ore, as it is called, should be again removed from the class of the last-mentioned species, and should resume the place which it formerly occupied among the white silver-ores.

## SIXTH SECTION.

# Grey Silver-ore (Graugültigerz).

That ore of filver which I here introduce with this new name, is erroneously called white filver-ore (Weisfgülden), at Kremnitz in Hungary, where it is dug up both in masses and in white quarz. This last appellation is the more improper, as, with regard to lustre and the colour of its fracture, it approaches nearer to the grey copper-ore (Fahlerz), than the white silver-ore (Weisgültigerz).

a) Three hundred grains of the fragments selected from the pounded ore, though not perfectly separable from the quarzose gangue,

gangue, with which they are firmly concreted, were levigated to a fubtle powder, and digested with four times their weight of nitric acid. The digestion was renewed with the residue, in an equal quantity of the same acid; and the portion which still remained undissolved then assumed a greyish-yellow colour, and weighed 188 grains.

- b) By the addition of muriat of foda to the bright-green mitric folution, its filver was thrown down; and this precipitate, collected and reduced by means of foda, yielded 31½ grains of metallic filver.
- c) The filver being thus feparated, I tried the folution for lead; but neither the neutral fulphats, nor free fulphuric acid, could discover the least fign of it.
- d) After this I added caustic volatile alkali, so as to superfaturate the acid; upon which a brown-reddish precipitate, of a loose cohesion, appeared, that by ignition became of a black-brown, and weighed 9½ grains. It dissolved in nitric acid, leaving behind it half a grain of filiceous earth. Prussiat of pot-ash produced from the filtered solution a deep-blue precipitate of iron; and after this was separated, 1½ grain of alumine were obtained from it by means of soda. Therefore, subtracting the siliceous and argillaceous earths, the portion of iron attractible by the magnet amounted to 7½ grains.
- e) To the folution, which had before been over-faturated with pure ammoniac, and exhibited a blue fapphirine colour, fulphuric acid was now added to excess. A polished piece of iron was then immersed into the sluid, from which it precipitated 69 grains of copper.

- f) The above greyish-yellow residue (a) was now to be examined. I digested it with six times its quantity of muriatic acid in a heat of ebullition. When siltered, the residue which was lest on the paper being first washed with muriatic acid, then with a little alkohol, and lastly dried, was found to weigh  $105\frac{1}{2}$  grains.
- g) From the folution which was obtained by the last process, and was of a straw yellow, the greater part of the sluid was drawn off by a gentle distillation in a retort. The remaining concentrated solution then deposited some crystalline grains, which were carefully collected, and proved, upon inquiry, to be muriated silver, that afforded a bead of silver, weighing  $\frac{1}{4}$  of a grain. A large quantity of water being next poured into the solution, a copious precipitate subsided, weighing, after desiccation,  $97\frac{1}{4}$  grains. It proved, by every test, to be oxyd of antimony, for which, as I have sound by comparative experiments, 75 grains of reguline antimony must be allowed.
- b) The refidue obtained at (f), weighing  $105\frac{1}{2}$  grains which comprised the sulphureous part of the ore, I exposed to a low heat, by which treatment the sulphur was consumed, and  $80\frac{1}{4}$  grains of siliceous earth remained. Hence the quantity of the sulphur was equal to  $25\frac{1}{4}$  grains.
- i) The filiceous earth was next fused with four times its weight of black flux. The melted mass entirely dissolved in twice its quantity of water into liquor of flints; some minute particles of filver, weighing  $\frac{3}{4}$  of a grain, excepted. According to this, the proportion of filex amounted to  $79\frac{x}{2}$  grains.

Whence the conflituent parts here obtained are:

Silver	6)	Install	31=7	2310	anony-h	in otide
given it	g) .	Lion,	4	generic	32 1 gra	ins.
					SAFE NOAL	g to eme
Copper	e) .				69	
Reguline	e Antin	iony g)	that al	afidered	75	nedly
Iron	d) .	gai entir	ry cont	county,	74	
Sulphur	b) .	to one o	mounts	is ylledly at	25±	
					$I\frac{I}{2}$	
Silen de	d)	on an	1/2 Z	there	80	
						dher out
in anot		our side		والمال والالا	TH 00 1	orga at a

consider al roug south a 290 grains.

But as the filiceous earth does not belong to the real mixture of the ore, but only arises from the admixed particles of quarz, it follows, that, when these are excluded from the computation, the true constituent parts of the grey filverore here examined, are, in the *bundred*, as follows:—

Silver	14,97 parts
Copper	31,36
Reguline Antimony .	34,09
Iron	3,30
Sulphur	11,50
Alumine	0,30
	Distriction of the last of the

95,32

As, therefore, the foregoing analysis plainly shews that no lead is contained in this filver-ore from Kremnitz, it cannot be any longer classed with the white silver-ores. For the same reason it would be equally improper to reckon it among the grey copper-ores: but, from the considerable proportions of noble metal which it contains, it has a just claim to the rank of a silver-ore, more so than even the

white and poorer ores of that metal. Therefore, from analogy with the generic appellation, I have given it the name of grey filver-ore.

When it is confidered that all the filver procured from the ores in Lower Hungary contains a portion of gold, and that this portion usually amounts to one drachm (4 denarien) in the mark of the refined filver, which, in Kremnitz, is coined into money, there remains no doubt that the ore here analysed likewise contains gold, as, indeed, some traces of it appeared in the course of this investigation. But it would have required a distinct process, performed too with a greater quantity of the ore, to have ascertained the proportion of gold contained in it; which, however, was beyond the limits of the present inquiry.

According to an information given to me as authentic, this ore is faid likewife to contain mercury. Therefore, though no indication of this metal occurred to me during those experiments, I thought it worth while to institute a particular inquiry on that point. For this purpose I mingled 200 grains of the ore with 100 of quick-lime; and having put this mixture into a small retort, connected with a receiver, filled with water, I exposed the vessel to the fire, increasing the intensity of heat until it became red-hot: but no perceivable trace of mercury appeared.

### SEVENTH SECTION.

Native Amalgam of Silver.

Besides the sulphurated ores of silver, various other metallic mixtures are sound in the mineral kingdom, in which which the filver, unaccompanied by sulphur, enters as a constituent part. To these, among others, belongs the solution of filver in mercury, or the native silver-amalgam, which occurs chiesly in the quick-silver mines, and, in various forms, in the Duchy of Deuxponts.

In order to ascertain the proportion of these two metals to each other, I employed the amalgam, which is found in folitary, garnet-like crystals in the mine called Vertrauen auf Gott, at Moschellandsberg. Some pure crystals of this amalgam, weighing together exactly 331 grains, were inferted into a barometer tube, of a diameter somewhat larger than usual, the lower end of which had been closed by fusion. This end being placed in fand, within a small crucible, I applied heat to it, increasing its intensity gradually and flowly to the degree of ignition. After cooling, I cut off the lower end from the tube, and found that it contained the filver, which had undergone ignition, in its former crystalline form, and weighing 12 grains. On collecting the mercury that had been sublimed in the tube, I obtained 21 grains. Therefore, fince the deficiency of 1 of a grain may be reckoned as a lofs of quickfilver, the following will be the proportion of the parts in one hundred of this crystallized amalgam of filver: namely,

Silver . . . 36
Mercury . . . 64

### EIGHTH SECTION.

# Arfenical Silver.

Another example of a metallic mixture, containing filver free from fulphur, is the native arfenical filver. Its proportion of filver varies from a few half ounces to feveral marks (of 8 ounces) in the centner, or one hundred pounds. Among the richer forts of this ore, I felected the specimen, the analysis of which is here given, and which was dug up from the mine Samfon, at Andreasberg. Its gangue consists of white, coarsely-lamellated calcareous spar, in which the arsenical silver is contained, partly in lumps, partly disseminated in coarse grains, but without any other kind of extraneous ores.

- a) At first I separated from the general mass, coarsely pounded in the mill, those pieces of calcareous spar which contained no portion of metal. Then I continued pouring distilled vinegar on the picked ore, till the calcareous spar that still adhered was entirely dissolved and separated. Lastly, when the ore had again become dry, I reduced it into a sine powder.
- b) Upon two hundred grains of the ore, thus purified and pulverized, I poured nitric acid of moderate strength, by which it was attacked with great vehemence. When sufficiently digested, the solution was separated, by digestion, from the dirty yellow residue, which, upon drying, weighed 71 grains.
- e) On combining it with common falt, disfolved in water, muriat of filver precipitated from the folution. This horn-

horn-filver was then freed from moisture, and fused in a filver-crucible over a gentle fire; during which process it emitted some arsenical vapours. Its weight was 28 grains, equal to 21 grains of metallic filver.

- d) The filver being thus removed, I faturated the folution with vegetable alkali, procured from tartar. A light-red and very intumescent precipitate fell down, which, on drying, was rendered of a deep-brown. Ignition made the brown colour disappear, and the precipitate now exhibited a light greenish-grey powder, inclining to white, and which weighed 160 grains. Being convinced that it was arseniated iron, I put it on a roasting test, mingled with one fourth part of powdered charcoal; and applied a low redheat. By this treatment the arsenic became revived, and escaped in white vapours. The remaining iron was again repeatedly roasted, with the addition of charcoal-dust, till no arsenical smell could be any longer observed. The iron which at last remained had a black colour, weighed 106 grains, and perfectly obeyed the magnet.
- e) The 71 grains (b), that continued undiffolved in the nitric acid, were digested with muriatic acid, and towards the end were once more combined with a sew drops of the nitric acid. Nearly all the powder was dissolved, excepting a small residue, coagulated like curds of cheese; which proved to be muriated silver, and by reduction with soda furnished a button of silver, of  $4\frac{1}{2}$  grains.
- f) By dilution with water, this muriatic folution was rendered turbid, without any precipitation. But by faturating it with falt of tartar, a yellowish-green sediment appeared, which, when collected, dried, and ignited, was found to weigh 32 grains. Upon dissolving it again in a small quantity of muriatic acid, a white precipitate was pro-

duced

duced by the affusion of water; the quantity of which, when dried in a warm temperature, amounted to  $10\frac{x}{2}$  grains. On farther trial, it proved to be unquestionably an antimonial oxyd; still containing, however, a slight trace of arseniated iron. I estimate that oxyd at 8 grains of reguline antimony.

- g) What remained of the muriatic folution afforded, by combination with the above vegetable alkali, a precipitate, which, when dried and roasted, like the preceding (d), with pulverized charcoal, yielded 18 grains of oxyded iron.
- b) Desirous of affuring myself of the absence of sulphur, I subjected 200 grains of the powdered ore to sublimation, in a small retort. Nothing but pure reguline arsenic was raised; which, as usual, fixed in the neck of the retort, in the form of a crust of a metallic lustre, composed of an accumulation of small crystals.
- i) It is then evident, that this ore confifts of filver, iron, arfenic, and antimony. However, when we reflect that the arfenic, during the treatment of the ore with acids, combines with oxygen; and farther, that part of it is driven off in the oxyded state, on the process of roasting, and that part of it is taken up by the water employed for washing the precipitates, the acid of arsenic being of easy solution in water, it is obvious that there exists a degree of uncertainty in the attempt to ascertain, with accuracy, the proportions in which those ingredients are united. Nevertheless, the proportion of arsenic may be computed, with propriety, from the loss of weight requisite to make up the whole weight of the three remaining constituent parts, in the following manner:

Silver c) $\cdot \cdot \cdot$	. 25½
Iron,	
Oxyd of iron attractible	e zalanga
by the magnet $\begin{pmatrix} d \end{pmatrix}$ 106 $\begin{pmatrix} g \end{pmatrix}$ 124	onerson.
which gives of metallic iron	. 88 <u>r</u>
Reguline antimony	. 8
ma energy place destroying application	122
The arfenic, therefore, would make (200—122=78)	78
delatificación of regis fraction. It is veca	200

However, fince, in the processes of chemical analysis of this as well as of other species, some loss always unavoidably occurs in the sum of the products, amounting from 2 or 3 to 5 or 6 in the hundred, regard must here be had to this circumstance. Therefore, if the mean number of the loss, which is 4, be subtracted, 70 will be left for the arsenic.

Hence, according to these premises, the arsenical silver examined in this analysis contains, in an hundred parts,

Silver	1					12,75	
Iron						44,25	
Arsenic					i	35.	
Regulin	re a	ntin	mon	у.		4	
					,	- AND	-
						06	

Besides the above eight species of silver-ores, the analysis of which have made the subject of the present essay,

other kinds of argentiferous ores and metallic mixtures occur. But the greatest part of these cannot be fairly considered as species of the genus of silver-ores; because the proportion of the noble metal which they contain is too inconsiderable, when compared with their other constituent parts.

In general, I should not wish to recommend the method hitherto used in the systematic arrangement, of denominating ores by the constituent part, which is of the greatest mercantile value; though, on the other hand, I do not venture to assert, that, at the present period, the predominant constituent part alone should serve as the principle, upon which to establish the classification of sossil bodies. If it were so, we should only retain under the genus of silver (besides the native silver) the corneous, the red, the vitreous, and brittle vitreous silver-ores; together with the black silver-ore (silver-mulm), which I had no opportunity to examine. And, on the contrary, the white silver-ore would then necessarily come under the genus of lead; the grey under that of antimony; the silveramalgam under that of mercury; and the arsenical silver under the genus of iron.

It is only by increasing our knowledge of the chemical composition of individual species of fossils that we shall be able to erect, on the relics of the present system of mineralogy, another, which shall possess a more solid foundation, and shall be more conformable to nature.

X.

## EXAMINATION

OF THE

## ORIENTAL LAPIS LAZULI.

THOUGH the researches of Marggraf have resuted the opinion, formerly received, that the blue colour of the Lapis Lazuli originated from an admixture of copper; and though it has been demonstrated that the colour of this fossil is owing only to iron, yet its other constituent parts have not yet been determined with due accuracy. For this reason, I thought that a farther examination of it would not be superstuous.

Marggraf\* mentions, indeed, and very justly, lime, gypfum, and filex, as the other constituent parts of the lapis lazuli, besides a quantity of iron: but this account is still incomplete, as he takes no notice of their respective proportions, and has, besides, entirely overlooked the aluminous earth which it contains.

Rinmann + assures us, that this stone, besides iron, calcareous earth, and quarz, contains also fluoric acid. Never-

<sup>\*</sup> Marggraf, Chim. Schristen I. Theil. Berlin, 1768, page 121.

<sup>†</sup> Rinnmann, Geschichte des Eisens, 2 B. Berlin, 1785, page

theless, I could not ascertain the presence of the latter. Rinmann's supposition was probably occasioned only by the phosphorescent light which issues from the lapis lazuli, when heated.

Cronstedt, and others likewise, suppose the existence of silver in this mineral, amounting to two ounces in 100 pounds; but neither could I discover any clear indication of this ingredient. I chose, for the following inquiries into the nature of the lapis lazuli, a pure specimen of a deep-blue; and I first endeavoured, as much as possible, to free the fragments from the white spots, and the particles of sulphur-pyrites with which this stone is always mixed.

a) Hundred parts of lapis lazuli lost two parts in weight, by being ignited for half an hour in a porcelain crucible. Its colour sustained no change.

o it has been demonstrated that the folonic of this

From this confiderable permanence of the beautiful blue colour, I was induced to try whether it would admit of being employed as an enamel colour, especially as Bergmann had already conjectured that the Chinese and Japanese probably used the lapis lazuli to impart the blue colour to their porcelain. With this view, I caused the powder, finely ground with a suitable flux, to be put upon porcelain, and had it baked in an enamelling surnace. My expectation, however, proved abortive; for the colour was altered, and had passed to an ash-grey.

b) But in a stronger and more continued fire, the lapis lazuli becomes completely vitrified, and loses 12 per cent; as has been already mentioned in No. 51 of my Essay on the Habitudes of various Species of Earths and Stones in Fire. The two parts that escaped from the hundred, during ignition for half an hour, cannot well be taken for any thing

thing else than water. But the other 10 parts, which the stone loses in a more intense heat, probably consist of carbonic acid; since the efferv escence of the lapis lazuli, when covered with any acid, weak as it is, shews that a part of its calcareous ingredient is dissolved in that menstruum.

- c) Two bundred grains of finely levigated lapis lazuli were digested in a retort with muriatic acid, weakened by an equal quantity of water. The blue colour of the pulverized stone gradually turned to ash-grey. When the mixture had reached a boiling heat, the powder was acted on with greater vehemence by the acid, and, after some ebullition, it formed a cheefy-coagulum. I then diluted it with more water, added one part of nitric acid, and kept it boiling till the insoluble residue had assumed a white colour. The solution, afterwards separated by filtration, was of a pale yellow.
- d) The residue had a sandy appearance, and weighed 138 grains after drying. It was subjected to ignition with three parts of caustic, or pure pot-ash. The greenish mass which resulted thence, when softened with water, afforded a colourless solution, from which muriatic acid, added to excess, precipitated siliceous earth, weighing 57 grains when ignited.
- e) This same solution (d), mixed with the above (c), and decomposed in a boiling heat by carbonat of pot-ash, yielded a yellowish-white precipitate, which, upon defication, weighed 221 grains, and entirely dissolved in muriatic acid.
- f) Caustic ammoniac threw down from this solution a gelatinous precipitate, which, when digested with caustic M 3

alkaline lye, was not totally diffolved, but left a yellowishwhite residue, of 113 grains, in its dry state.

- g) By combining the liquid that remained from the precipitation by ammoniac, with carbonat of pot-ash, in a boiling heat, 59 grains of carbonat of lime, or mild calcareous earth, were obtained.
- b) Upon the 113 grains, not taken up by the caustic lye, I poured dilute sulphuric acid. The mixture coagulated in heat to a gelatinous consistence. When covered, and digested with a large proportion of water, there separated from it siliceous earth, the quantity of which, after being heated to redness, was 29 grains.
- i) After the filex had been separated, the solution was mixed with ammoniac, and the precipitate thus formed was conveyed, while yet moist, into boiling caustic Iye. A brown flocculent precipitate remained, which weighed, when dry, 13 grains. After they had been dissolved in muriatic acid, caustic ammoniac precipitated oxyd of iron, weighing 6 grains. After desiccation, by adding carbonated ammoniac to the remaining fluid, 5 grains more of caleareous earth were thrown down.
- k) The alkaline folution (f) and (i) were then faturated with muriatic acid. By this all that the alkali had taken up was feparated; and this, when re-diffolved, by an additional portion of the same acid, I again precipitated by carbonated pot-ash. On re-diffolving this last precipitate, in dilute sulphuric acid, there appeared another portion of silex, which, after ignition, was found to weigh 6 grains. The sulphuric acid, when poured off, and combined with a due proportion of pot-ash, afforded crystals of alum, which were re-dissolved, and their aluminous earth precipitated

by means of mild, or carbonated alkali. After the alumine had been properly purified, deficcated, and exposed to red heat, its weight amouted to 29 grains.

l) I had before convinced myself, that in the lapis lazuli the whole of its calcareous earth is not combined with carbonic acid, but a portion of it with the sulphuric acid. For this purpose I boiled a portion of pulverized lapis lazuli with a large quantity of water; which, when filtered, had an opaline appearance. Muriated barytes being then added as a test, some sulphat of barytes was formed. In order to discover the proportion of the sulphat of lime, or gypsum, contained in this stone, I took the sluid remaining from the precipitate mentioned at (c), together with the edulcorating water, and, after super-saturation with muriatic acid, I examined it with a solution of muriat of barytes. The result was a precipitation of sulphat of barytes which, collected and highly dried, amounted to 19½ grains.

It was reasonable to conjecture, that not only the gypsum contained in the lapis lazuli, but also an accidental admixture of fulphat of pot-ash, in the caustic and mild alkali employed in the processes (d) and (e), might have contributed to the formation of the fulphated barytes. Therefore, to ascertain this point, I dissolved a similar quantity of each, adding then muriatic acid, fo that the acid predominated; and, lastly, I combined the whole with muriat of barytes, In the refult, there appeared 11 grain of fulphat of barytes. collected with care. An equal quantity, therefore, is to be deducted from the above 191 grains. On this account, the above-mentioned 18 grains of fulphated barytes were the proper scale, or measure, by which to determine the proportion of the gypfum fought for in the prefent instance; and, calculating upon this ground, it followed, that the above 200 grains of decomposed lapis lazuli contained

8,18 grains of free fulphuric acid of 1,850 spee. grav.; or, if taken in combination with the lime which enters into that stone, 13 grains of gypsum. This computation is founded on the results of my experiments: first, that, disregarding minute fractions, 100 parts of sulphuric acid of the above-mentioned specific gravity, when saturated with barytes, yield 220 of sulphat of barytes; and, secondly, that the same quantity of sulphurie acid, when saturated with calcareous earth, forms 160 parts of gypsum: observing, however, that 100 parts of crude calcareous earth, or carbonat of lime, are required to saturate the acid; but only 55 parts of pure, or burnt lime.

Confequently, these 200 grains of Lapis Lazuli give the following remote constituent parts:

Lime d)	57	considiary a se
(b)	29	. 92 grains.
k)	6)	If was realonable
Silex g)	59	mained in the hope
we Marie black bug with	in id id al -	wer to reduced to ive
might have contidute	(4)	ignited 35
Alumine k)	September 1903	29
Oxyd of iron i)	1 2 2 2 1 1 1 1	6
Sulphuric acid 1)		8
Carbonic acid b)		20
Water a)		4
meetic and all sea		Corty and the Barbara
adplayed by the wer	to calling Ben	194 Lofs . 6
of sainter to it entitles to	regament by	10 min Togota 9
the probate that the		200 grains.
		the Continues of the

But

But fince the calcareous earth, in the present subject of inquiry, is combined partly with sulphuric acid, partly with the carbonic, the following must be reckoned as the proximate constituent parts of the lapis lazuli:

Silex .								46
Alumine								
Carbonat	of	lim	e					28
Sulphat of	f lin	ne	(gy	psur	n)			6,50
Oxyd of	iron	,				*		3
Water								2
							-	-

100

The reason of this exact agreement of the sum of the constituent parts with the weight of the whole, is, that I have supposed the carbonat of lime to be completely saturated with the carbonic acid; which, however, does not seem entirely to be the case.

XI

## EXAMINATION

OF

# A SMALT-BLUE FOSSIL, from Vorau\*

AMONG the mineralogical notices, given in a letter from Vienna, inferted in the third volume of the Observations and Discoveries in Natural History, page 352, mention is made of a newly-discovered blue fossil from Vorau, in Austria. It was, at first, taken for native smalt, then for native Prussian-blue, and, lastly, for mountain-blue, or azure copper-ore.

This fossil is of a deep smalt-blue, accompanied with a grey-white quarz, of an imperfectly conchoidal fracture, (Fettquarz), with which it is firmly concreted, and crossed by a band of shiftose mica, from  $\frac{1}{4}$  to  $\frac{1}{2}$  inch thick, consisting of grey-white granular quarz, and a little mica of a silvery-white. It partly forms the seam, or joint (salband) of this small vein; partly it is finely diffeminated through the quarz, and sometimes it approaches to the size of a hazel-

<sup>\*</sup> Beobachtungen und Entdeckungen aus der Naturkunde 4 Band. Berlin, 1792. Seite 90.

nut. When in the latter state, a crystalline form of quadrilateral statemed columns, or tables, is observed; though, on account of the quarz, which is perfectly concreted with it, the exterior, unbroken surface only, in some parts, exhibits the crystalline form. On these facets the fossil is even, and of a moderate lustre; but in the fracture, which is compact and rough, it is only glittering. It is opake; its streak of a somewhat lighter blue; its hardness nearly that of quarz.

No fign of any volcanic product presenting itself in this fossil, it was obvious, from the very mode of its appearance, that it could not, by any means, be a native smalt: for, must not the agency of fire have been present, to form a stony matter, naturally coloured blue by means of cobalt?

The following fhort narrative of my refearches concerning this fossil, will also prove, that it is as far from being a mountain blue, or containing oxyded espper; not-withstanding that this is given as the result of the chemical experiments made with it at Vienna.

Finding that all the acids which I poured upon this mineral, previously reduced into fine powder, and freed as much as possible from the affociated quarz, would not attack it with the requisite force, I subjected it to a low redheat, combined with twice its weight of pot-ash, procured from tartar. After refrigeration, I observed that the blue colour had entirely disappeared, and the mass had assumed a yellowish-white. When this had been triturated, softened in water, then saturated to excess with nitric acid, digested and siltered, there remained undissolved siliceous earth. The solution had no colour. In one part of it I immersed polished iron; but neither copper, nor any other metallic

fub-

fubstance would precipitate. To the remaining portionprussiate of pot-ash was added, and thus a deep-blue precipitate was produced, which, after ignition, was attracted by the magnet. From the solution, separated from this last by filtering, liquid caustic ammoniac threw down some alumimous earth in a slimy state. But the remaining stuid suffered no change, on the addition of carbonat of pot-ash.

Silex, alumine, and oxyded iron, are then the conflituent parts here discovered. But their respective proportions remain to be ascertained by new experiments, to be performed with a greater quantity of this fossil.

As, therefore, not the flightest trace of copper can be found in this fossil, it is obvious that it cannot in any respect be considered as a mountain-blue.

Nor can I take it for a native Prussian blue, which it was confidered to be, in consequence of an inquiry made into its nature at Chemnitz. Its portion of iron affords no argument to the contrary; and the grounds of my opinion rest upon the following observations.

- is a) The native Prussian blue is found only in moorish grounds or fens, and in thin strata. It occurs immediately under the vegetable mould, and appears in the form of a loose white earth, that becomes blue only when exposed to air.
- b) This blue foffil, on the contrary, is concreted with a hard vein of quarz, which is inclosed in a stony matter of equal hardness. Besides, its blue colour shews itself directly on every recent fracture; which indicates that the fossil was previously possessed it.

- 2. a) Native Prussian blue is immediately deprived of its colour by fire; at first it becomes brown, then of a brick-red, and lastly it melts into globules of a metallic lustre.
- b) The fossil from Vorau falls instantly in pieces, when urged by the fire. Its cohesion is thereby loosened, and it assumes the form of a light-grey slocculent earth; but without shewing the least disposition to sufe.
- 3. a) With borat of foda, and with the phosphats, the native Prussian blue runs into a black untransparent scoria.
- b) But the fossil from Vorau yields, when fused with borax, a clear, faint, topaz-yellow glass; and with a neutral phosphat\*; a clear, colourless glass.
- 4. a) The native Prussian bine directly liquestes in acids, when poured upon it.
- b) On the contrary, the foldil from Vorau is with difficulty acted upon by acids.
- 5. a) Caustic alkaline lye instantaneously changes the colour of the native Prussian blue into a brown.
- b) But the colour of the above fossil is not at all altered by it.

<sup>\*</sup> The author constantly uses the expression Phosphorsalz, whereby concrete phosphoric acid might be understood: but most probably he means a neutral phosphat, and especially the phosphat of soda, which, on account of its property of promoting sussion in an eminent degree, is chiefly employed by mineralogists and chemists in examining substances with the blow-pipe.—Hence, the translator substitutes, in all similar cases, the term neutral, or alkaline phosphat. Trans.

In the native Prussian blue, the oxyd of iron is combined with phosphoric acid; as I have proved in another place\*. But it is still unknown, by what substance the oxyd of iron, contained in the fossil from Vorau, is modified so as to acquire the blue colour.

Another instance of a similar blue colour imparted by fron, is afforded by the *Oriental lapis lazuli*. It differs, however, from the preceding, in this, that its blue colour is considerably more permanent in the fire; for, so long as the stone is but moderately ignited, its colour continues unaltered, and is changed only when the stone is urged by a stronger heat, and is brought into the state of suspending. The lapis lazuli is also distinguished from the fossil from Vorau, besides its other constituent parts, by a proportion of calcareous earth, which is the cause of its melting in fire.

If the above fossil likewise contained lime, I should not hesitate to range it as a variety of the lapis lazuli; as has been already done by Mr. Stütz+, with the name of spurious lapis lazuli. Perhaps may the denomination lazulite be not quite improper.

Note. I have once mentioned that fossil, as a particular species of ferruginous earth, or oxyded iron, with the name of iron-blue from Vorau; but its proportion of iron seems to be too small to entitle it to that place.

<sup>\*</sup> Chemische Annalen. 1784. 5tes Stuck. Seite 396.

† Neue Einrichtung der K. K. Naturaliensammlung zu Wienn.
Wienn, 1793. Seite 49.

[ 175 ]

XII.

## CHEMICAL EXAMINATION

OF THE

# CIRCON, OR JARGON OF CEYLON.

# FIRST SECTION\*.

AMONG the rough or uncut precious stones coming from Ceylon, there occurs a particular genus, hitherto little noticed; which is distinguished from other gems by the following characters.

Its colour confifts of various shades of pale yellow-green, and reddish, altogether inclining to a dim smoke-grey. Externally, a greasy gloss is observed, and it feels smooth. The fize of the individual stones is inconsiderable; commonly 20 or 30 of them weigh only one drachm. The primitive figure of their crystals is a rectangular four-sided column (parallelopipedon), with tetrahedral terminations, the surfaces of which rest on those of the column. However, this form of crystallization is distinctly perceptible in

<sup>\*</sup> Auszug aus den Beob. u. Entdeek. aus der Naturkunde. 3 B. 2 St. Berlin, 1789.

very few specimens only; as for the greatest part they are merely loose, minute, rounded grains (abgerundete geschiebe\*.)

But this kind of gems is eminently diffinguished by its specific gravity, which I have found to be 4,615+.

Romé de l'Isle was the first, to my knowledge, who mentions these gems as a particular species of stones; giving them the name, fargon of Ceylon, and stating their weight, according to Brisson's experiments, at 4,416. Other mineralogists and writers, who notice this stone, class it—some with the sapphire, others with the topaz, others with the ruby, others with the diamond, and some with the hyacinth. But Werner has assigned to it a peculiar place in the mineralogic system, immediately under the diamond, and the chrysoberyl, and called it Zircon (Silex cirnonius.)

The jargons do not lofe much of their weight by ignition; for, upon igniting 300 grains for the space of one hour and a half, and with the greatest intensity of heat, I found the loss to be only one fourth of a grain. This ignition I repeated three times, and quenched them after each process in water. The stones became by this rifty: the brighter ones loss their smoke-grey appearance, and were rendered similar to cloudy white-grey quarz; but some of the darker specimens, as well as some parts of the brighter, turned reddish. Their natural hardness, however, did not seem to have been impaired.

<sup>\*</sup> A more circumstantial description has been given by Emmerling, in his Lehrbuch der Mineralogie, I. Th. Giessen, 1793; and by Widenmann, in his Handbuch der Mineralogie, Leipzig, 1794.

<sup>+</sup> Yet I have afterwards found a difference in the specific gravity of the various species; however, the least weight that I observed was as high as 4,530.

#### A.

- a) By way of a preparatory analysis, 200 grains of jargon were levigated in a slint-mortar to a very subtle powder of a white colour, inclining to a pale sless-red, which I mingled with equal parts of carbonated pot-ash, exposing it to a red-heat for one hour in a silver-crucible. It then formed a conglutinated mass, which, upon trituration, I saturated to excess, and digested with muriatic acid. But this did not at all appear to attack it, as I obtained again the jargonic powder without the least alteration, and with the loss of only half a grain.
- b) For this reason I afterwards blended the same powder with six times its quantity of the above alkali, prepared from tartar, and ignited it strongly during sive hours. The mass was rendered compact, and brought to the point of sustaining the same series with the muriatic acid added to excess, the powder of the stone was likewise sound but little altered; and, after washing, drying, and ignition, I recovered it with no more loss than two grains.
- c) Upon this, I once more added 1200 grains of the above alkali, and kept the mass in an ignited state, until it actually suffed; which, after being again super-saturated with muriatic acid, lest behind it 197 grains of undecomposed jargon.
- d) I next put this powder into a retort, and poured upon it five times its quantity of strong sulphuric acid, adding to it one ounce of water; and when the liquor had been dif-

The obstinacy with which the jargon resisted every attempt to decompose it in the above manner, abated my ardour in pursuing farther this experiment. But, having in the mean time become acquainted with the powerful efficacy of caustic fixed alkalis in loosening the cohesion of particles in the various species of gems, I resolved to employ them also for the jargon, and proceeded to the following new experiment.

#### B

a) Two hundred grains of finely pulverized jargon were ignited for two hours in a filver-crucible, with four times their weight of caustic soda, and with such an intensity of heat, that the mass continued in a state of pulpy or thick sustained. Upon refrigeration, the mass proved to be very hard, and was gradually softened by repeated affusion of hoiling water. The alkali seemed to have totally lost its former causticity, the solution tasting like a weak carbonated lixivium. When it had been sufficiently super-saturated and digested with muriatic acid, I did not observe that any siliceous earth separated; and the undissolved residue remained behind on the siltering paper in the form of a fine sand-like powder, weighing, after desiccation and ignition, 172 grains.

b) That

- b) That refidue, when again treated in the same manner with sour times its weight of caustic soda, afforded a very firm porous mass, which, after being digested with muriatic acid, in the manner related, lest behind 148 grains of jargonic powder.
- c) The same process of adding to it sour times its weight of caustic soda, and subsequent digestion in muriatic acid, was repeated with this last. After this treatment, there still remained 127 grains.
- d) This, treated again for the fourth time in the same manner, left 97 grains.
- e) As my stock of caustic soda was now exhausted, I prepared, instead of it, a caustic vegetable alkali, and added to the above undecomposed 97 grains of jargon six times their weight of the above alkali, and kept the mass, during several hours, in as intense an ignition, as the silver-crucible was able to bear without melting. However, its susion went on but slowly, and was of a pulpy consistence. Even boiling water would but difficultly liquesy the refrigerated mass. But, when it had been saturated to excess, and digested with muriatic acid in the degree of boiling heat, a total solution of the jargon ensued.
- f) I now poured together all the several preceding solutions. The whole of them exhibited a transparent sluid, but somewhat opalescent, and with a few light sloculent particles floating in it. I then saturated this liquor with carbonated, or mild pot-ash. The earth, which separated by this management, gave to the mixture an appearance of milk. But when collected on the filter, and washed, it first assumed the form of paste made of starch, and afterwards dried up to lumps of a vitreous appearance, and of a

whitish colour, verging upon the grey-green. The fluid filtered off from it, together with the washings, still depofited in a warm temperature a small portion of earth, which I added to the above precipitate.

- g) This precipitate contained now all the conflituent parts of the jargon under examination, but deprived of their native cohesion. One half of it I digested with one ounce of strong muriatic acid, in a heat of considerable intensity, and thus I obtained a turbid yellowish solution, from which the undissolved part slowly subsided upon dilution with water. After the superincumbent liquor had been decanted, and the residuum digested with an equal quantity of boiling muriatic acid, I filtered the solution, and dried the undissolved residue, which still remained.
- b) As, in this inflance, it was my principal defign to difcover, whether any calcareous earth was prefent, I precipitated the diffolved portion from the muriatic folution by means of caustic ammoniac. It fell down as an extremely loose substance, resembling a transparent slime. But neither carbonated ammoniac, nor carbonated pot-ash, would produce the least turbidness, when added to the separated clear liquor. This shews, that it contained no calcareous earth; which was also confirmed by several other tests or re-agents employed for that purpose.
- i) Upon the fecond half of the above precipitate (g) I affused a triple quantity of concentrated sulphuric acid, and abstracted it again by distillation to dryness. From the residual mass again softened with water, and which looked like dissolved starch, I separated the undissolved part by filtration. But the filtered sulphuric solution, which was as limpid as water, when combined with various precipitating media, exhibited

exhibited precifely the same phenomena with those shewn by the foregoing solution, prepared with muriatic acid.

- k) The whole of the earth, which remained from both folutions (g) and (i), weighed, after ignition,  $86\frac{1}{2}$  grains, and refembled a fine fandy powder. It was then mingled with four times its weight of carbonated pot-ash, and subjected to ignition in a silver-crucible, until it entered into complete sussion. When the mass was again softened in water, it was found still hard, and of difficult solution. However, a very subtle, heavy, and, apparently, tenacious earth, was deposited, which, collected and ignited, was found to weigh  $28\frac{1}{2}$  grains.
- 1) The clear and colourless alkaline lixivium I divided into two parts. One half of it I saturated with muriatic acid; by which treatment, a white, puffy, gelatinous earth separated, no portion of which, however, would re-diffolve, by adding a superabundant quantity of the same acid. The other half I sirst diluted with plenty of water, and then gradually saturated it to excess with muriatic acid. It continued clear and limpid; and by this I was convinced, that the above was merely filiceous earth; which, therefore, after deducting the  $28\frac{1}{2}$  grains of earth from the  $86\frac{1}{2}$  grains that were suffed with the pot-ash (k), amounted to 58 grains.

Note. This is the order of examination in which I proceed, with respect to those earths, which, on analysis, I have some reasons to consider previously as belonging to the siliceous genus. By this method I most surely avoid the error, perhaps not unfrequent, of immediately calling any earth, that on the first attempt does not appear to dissolve in acids, merely siliceous. I likewise largely dilute with water the alkaline solution of the siliceous earth, and combine it to excess with any acid—(in which case, however, no precipitate ensus, because the sili-

ceous

And when upon this I evaporate it to dryness, with the affistance of heat, and soften again the dry salt with water, I find the siliceous earth, that was before held in solution, at the bottom of the vessel, in the form of fine crystalline grains of fand.

- m) Those  $28\frac{1}{2}$  grains of earth, that were left behind on the treatment with alkali (k), I digested in a boiling heat, with an abundance of nitro-muriatic acid. A residue was left, weighing, upon ignition, 16 grains.
- n) These undissolved 16 grains, blended with fix parts of caustic pot-ash, were exposed for some hours to a red heat. The colourless sluid, which was siltered off from the mass when again liquested with water, was not rendered turbid by the addition of sulphuric acid. But when exposed to a raised temperature, it formed a gelatinous mass, which, aster thorough desiccation, and the separation of the remaining salt by subsequent affusion of water, less three grains of siliceous earth behind, in the form of sand.
- o) The remainder of the alkaline folution (n), was subjected to digestion with boiling aqua regia. The earth, contrary to custom, swelled into a slimy matter, and the liquor acquired a greenish tinge. I filtered the solution previously diluted with water; mixed it with the preceding, which was likewise prepared with nitro-muriatic acid (n), and added prussiat of pot-ash. The greyish-green precipitate thus produced, when heated to redness, weighed no more than half a grain. The portion of oxyded iron, thus detected in the jargon under examination, may therefore be estimated at one fourth of a grain.

Note. Some phenomena which appeared on examining this precipitate, obtained by means of pruffiated pot-ash, led me to suspect fuspect a slight trace of the presence of Nickel. However, since, on every subsequent examination of the jargon, no such indication any more occurred to me, I think the above appearance to have been merely accidental.

- p) Carbonated vegetable alkali, being then added to the nitro-muriatic folution, precipitated of a white colour the remaining portion of earth, which it still contained. This earth, upon examination, was found to be of exactly the same nature with that obtained from the first solutions.
- q) After the residual undissolved earth had been ignited, it weighed five grains. I consider this as the remainder of the rough jargon, which had eluded the attempts to decompose; it the farther analysis of which, from the minuteness of its quantity, could not be undertaken.

#### C.

I now proceeded to the closer examination of that part of the jargon, which was found to be foluble in acids.

a) According to the established rule, the above sulphuric solution (B. i) should be supposed to contain either magnessan, or aluminous earth, or a mixture of both. However, the taste gave not the least indication of either. On the contrary, it was hardly distinguishable from that of pure sulphuric acid, and but gently astringent. In endeavouring to crystallize it, I expelled a part by evaporation, combined the remainder with a proportionate quantity of pot-ash, and waited to see whether aluminous crystals would form. It is true, on farther evaporation, there separated a crystalline milk-white crust; which, however, could not be taken

for

for alum, but only fulphat of pot-ash, together with which a portion of the dissolved earth was deposited.

- b) To carry the experiment farther, I dissolved the above-mentioned faline sediment in water; and in order to collect the whole quantity of the jargonic earth, I likewise dissolved that portion of it, which I had recovered from the muriatic solution (B. g), by means of ammoniac, as well as that which I had precipitated by vegetable alkali, from the nitro-muriatic solution (B. p). Both these last I dissolved in dilute sulphuric acid, and added the solutions to the preceding.
- c) I now once more directed my attention to the metallic ingredient in the jargon, to detect which, I could employ only the prussiat of pot ash. The first portion which was added, produced in the colourless solution a dirty olivegreen; but subsequent additions, made by degrees, tinged the mixture of a deep-blue. After the blue precipitate had subsided, it was collected and dried. It weighed three grains; of which the proportion of iron may be estimated at a fourth part, that is, three fourths of a grain.
- d) Upon this I faturated the whole of the fulphuric folution with crystallized alkali, prepared from tartar; on which the earth, which separated, imparted to the mixture an uniform, milky appearance. The earth thus deposited and washed, was subjected, while yet moist, to the following experiments.
- e) In diluted and gently warmed sulphuric acid it dissolved without any effervescence, though it had been precipitated by carbonated alkali; which shews, that this earth has no affinity with carbonic acid. The sulphuric acid took up a large quantity of it. I continued adding this earth to

the acid, until the last portion gave the folution an opaline appearance; but this again disappeared on the addition of a flight quantity of fulphuric acid, so that the solution then became clear. After cooling, it congealed into a milkwhite, pulpy substance. For this reason I again added a little fulphuric acid, which, affisted by a low heat, rendered the folution again limpid, fo that it no longer coagulated in the cold. I then left it standing at rest in a low temperature, and after some days I found the greatest part of it shot into small, detached, and clear crystalline groups, in radii of a flattened quadrilateral columnar form, diverging from a common centre, and terminating in sharp points. Their tafte was but little four, and left on the tongue a flight astringency. When thrown into water, they soon and eafily diffolved, at the same time that they lost their limpidity and became turbid. The remainder of the folution still afforded some crystals of a fine granular form; and the last portion thickened into an irregularly shaped mass.

- f) Distilled vinegar, concentrated to a fourth part of its bulk by freezing, dissolved the earth with equal readiness, receiving from it the peculiar taste already mentioned. This acetic solution dried by heat into a pulverulent residue, deliquescing in the air.
- g) I likewise boiled a portion of the jargonic earth with a lye of concentrated and caustic lixivium of pot-ash, previously heated to boiling. The earth merely subsided in it in a loose, slocculent form, without being dissolved.
- b) It is, then, manifest, from the foregoing experiments, that the Jargonia, or jargonic earth, is entirely different from the aluminous. That it is equally distinct from the magnesian earth, has already been proved by the total absence of all magnesian taste in the sulphuric solu-

tion, as well as by its incapability of abforbing carbonic acid. However, that no circumstance might be left unexplored in this examination, I re-dissolved in sulphuric acid the portion that yet remained; and having saturated with carbonat of lime the solution heated to boiling, I siltered the sluid from it after cooling. But neither the taste, nor any other re-agents, could discover the smallest sign of magnesia.

i) When this earth was tried with the blow-pipe upon charcoal, the phosphoric salt proved unable to disfolve any part of it, although its action was long continued; for the earth remained in the clear globule of that salt without any alteration. Nor was it found in any way attacked, when sufed with soda in the small silver-spoon. However, it dissolved by degrees, completely, and without bubbling, in glass of borax; and the bead, thus produced, continued perfectly clear and colourless.

From the refult of these experiments concerning the properties and relations of the earth extracted from the jargon, I think myself justified in confidering it as a new, distinct, simple earth, before unknown; and at present I give it the name of Zircon-earth (Terra Circonia\*), until it may, perhaps, be found in other species of stones, or possessed of other properties, that may give rise to a more appropriate denomination.

In the mean time, I wish that the above facts may excite that attention which I think they deserve: in order to induce one or more eminent chemical analysts to repeat

<sup>\*</sup> In this country JARGONIA. Transl.

these researches, whereby the results of my own may be either confirmed or corrected.

The proportion of the ingredients, conflituting the jargon, is yet left to be determined. But it is obvious, that, whenever new conflituent parts are discovered, the nature of which is as yet entirely unknown, and which do not admit of being treated by the methods hitherto practifed, the determination of their proportions cannot be brought to that high degree of accuracy, which may be expected when the Chemist pursues a beaten path, and cannot want a chemical knowledge of the constituent parts which he meets with in the subject under his examination.

Hence, as from the two hundred grains of the jargon, subjected to this analysis, I obtained

200

And supposing that these remaining undecomposed five grains contain the same proportion of constituent parts, we may estimate the ingredients in 100 parts of the jargon to be the following:

Silex	1		PI W.	(e)	31,50
Oxyd of iron			 W.		0,50
Jargonia .					68

100

## SECOND SECTION.

SINCE repeated experience has shewn me the powerful influence which the caustic alkali, when employed in the liquid state, exerts in promoting a more complete decomposition of the harder species of stones, I could not avoid subjecting the jargon likewise to this method of treatment. But to avoid supersluous prolixity in this essay, I shall confine the circumstantial detail of these new experiments to that analytical process only, which I have sound the most convenient.

#### A.

- a) One hundred grains of selected jargons, previously comminuted in the steel-mortar, were ground with water to a most subtle powder, in the triturating dish-made of slint. When dried and ignited, they were found to have acquired one half grain of additional weight.
- b) The powder of these stones was next strongly digested in a menstruum, compounded of 1½ ounce of muriatic acid, and half an ounce of the nitric. Caustic ammoniac, poured into the filtered bright-yellow stuid, produced a yellowish-white precipitation, weighing two grains after drying. The iron, which this precipitate contained, was re-dissolved in moderately strong muriatic acid, poured upon it in the cold;

cold; another part of it remained undiffolved, and was feparated by filtration. The ferruginous contents of this last yellowish folution were again thrown down, in the form of brown, flocculent particles, by means of caustic ammoniac; after which they were collected and ignited upon charcoal. The precipitate appeared then in black, shining grains, which obeyed the magnet, and weighed the grain.

That portion which would not again diffolve, and which still preserved its former yellowish-white hue, I likewise heated to redness, upon a piece of charcoal. By this management it acquired a faint, dark-brown colour at the first moment of ignition:—a phenomenon which does not usually take place, except in the white oxyd of manganese. This portion weighed \(\frac{1}{2}\) of a grain.

- c) Upon the pulverized jargon, after treatment with acids, and adding the above-mentioned refiduum of \( \frac{3}{4} \) of a grain (b), I poured two ounces and a half of a caustic lye, in which the saline part made half the weight. The whole was then inspissated in a silver-crucible to dryness, and moderately ignited for two hours; by which treatment the mass preserved a pap-like consistence. When refrigerated, I softened the indurated, grey-white mass with water. The powder of the stone, thus separated from the alkaline lye, when washed and dried in a low-heat, now resembled elutriated chalk, and weighed 128 grains.
- d) I then faturated the clear alkaline lixivium (c) with fulphuric acid. By this it was not rendered turbid; but only after it had been evaporated to dryness, and the faline mass again softened with water, there appeared filiceous earth, amounting to three grains after ignition.

e) The above jargonic powder (c), being now prepared for solution in acids, I first affused upon it eight times its weight of water; and upon this mixture, which had assumed a milky appearance, I poured a sufficient quantity of dilute sulphuric acid. In this menstruum, assisted by heat, the whole of the powder (a few impurities excepted), dissolved into a limpid, colourless liquor. After cooling, there settled around the sides and bottom of the glass-vessel an irregular crust, consisting of white crystalline grains; which again dissolved upon assusing more water of a warm temperature. This being done, the colourless solution was evaporated with a low heat. At the beginning of the process it remained clear, but afterwards it coagulated into an uniform, pellucid jelly.

f) When this gelatinous coagulum had again been digested with a large quantity of water, it dissolved into the form of transparent, viscid grains; which, collected on the filter, and desiccated, resembled glassy sand. These being exposed to a red heat, with four parts of mild vegetable alkali, and the mass re-dissolved in water, lest behind 3 grains of earth. Sulphuric acid precipitated the siliceous earth, which was dissolved in the alkaline solution, in its usual slimy form. Its quantity amounted, after ignition, to 24 grains.

g) After those three grains of earth (f), had been redissolved in sulphuric acid, and, along with their solvent, added to the remainder of the foregoing solution, I precipitated the jargonic earth contained in that sluid, by means of a boiling lye of carbonated pot-ash. The precipitated earth, edulcorated and dried in the air, was of a moderately loose cohesion, of a white colour, a little inclining to that of slesh, and weighed 122 grains. One fourth part of it, when

when ignited, amounted to 17½ grains; which gives 69 for the whole.

Therefore, the constituent parts of the jargons, analysed, are, in one hundred,

Jargonic earth	g) .		69,
Silex	d) . f) .	. 3	
From which subtracted	a)	27	a walati.
Oxyd of iron	b)	1	26,50
appel by ones say the say the say one say and the word as a constant			96 • 4
		1 1 1 and	100

B.

I shall farther mention some of my other analytical processes, repeated on that subject under circumstances somewhat diversified, and also the observations which have occurred to me concerning the chemical habitudes, or relations of jargonic earth.

a) Both the accurate discovery of the proportion of the filiceous earth, and its thorough separation from the earth of jargon, are rendered highly difficult by their intimate union, as well as by their reciprocal solution of each other. This end I have attained, in the surest way, by the method just.

now described: and for this reason I recommend this as the best among several that I have attempted. However, there seems to obtain some little difference in the proportion of the siliceous earth, depending on the nature of the several varieties of the jargon; which is likewise made probable by the small differences in the specific weight of various specimens of this stone.

- b) If, upon the mass obtained by softening the jargon with water, after its ignition with caustic alkali, muriatic or sulphuric acid be immediately poured, to a slight degree of super-saturation, the whole is directly dissolved, clearly, and without residue. The earth precipitated by means of alkali from this solution, hardens, during desiccation in warmth, into transparent, vitreous, heavy, solid, and brittle lumps; which, in the moment they are removed from the heat, sly into small pieces, with vehemence and noise; some of which, if not inclosed in paper, are often thrown to a great distance. The higher the temperature in which the earth has been dried, the greater is the residue lest behind undissolved, when again conveyed into acid menstrua, for solution.
- c) It does not feem that the boiling of rough, pulverized jargon, in acids, is fully competent to extract completely their proportion of iron. If, therefore, the prepared earth of jargon be again diffolved in an acid, and combined with proffiat of pot-ash, the ferruginous remainder will appear in the form of a precipitate, sometimes of a Prussian-blue; at others, of a bright mountain-blue. But this precipitate is unable to indicate the true quantity of iron which it exhibits; for it consists not only of a small portion of oxyded iron, but also of a much greater part of jargonic earth, thrown down along with it, which afterwards resists a farther separation. It is, from the presence of this earth, united

united with the precipitated iron, that the above precipitate acquires a pale, reddiff colour after ignition, and is hardly attracted by the magnet.

Consequently, not so much with the view of ascertaining the proportion of the constituent parts, as to produce the jargonia absolutely free from iron, it is adviseable to redissolve the earth first obtained, in an acid, and to separate that small remainder of iron by prussiated alkali. The iron being thus got rid of, the earth of circon, now perfectly pure, should be at last precipitated by means of an alkali, in a heat of ebullition.

- d) To obtain the circon-earth in a state of easy solution in acids, it is necessary that, after precipitation and washing, it should be dried in a gentle heat only. Strongly ignited earth of jargon will not dissolve in acids, unless again previously prepared for that process by igniting it along with caustic alkali.
- e) When the jargonia is to be precipitated from acid folutions, by means of carbonated pot-ash, the point of saturation should not be exceeded; since, otherwise, in proportion to the excess of alkali added, it will, either in part or wholly, be re-dissolved in the sluid, and can only then be made to re-appear by adding fresh acid to the superfluous alkali. However, this earth is not re-dissolved, if the precipitation is performed by caustic vegetable alkali, though the sluid should happen to be super-saturated with the salt.
- f) Of all the acid folutions of jargonic earth, that which is prepared with muriatic acid has the greatest tendency to crystallize. If committed to spontaneous evaporation, the muriat of jargonia shoots into very slender, acicu-

# 194 XII. On the Jargon of Ceylon.

lar crystals, radiated in a diverging direction, which continue dry on exposure to air.

g) The jargonia is not at all disposed to vitrifaction; which is proved by the following experiment. A glass frit, composed of 60 grains of jargonia, and 40 grains of mild alkali prepared from tartar, was exposed, in a crucible made of clay, to an intense and long continued fire. But by this process not only was no union of these two substances effected, but they even entirely separated. The alkali fixed itself on the sides of the vessel in indurated grains; and in the middle the jargonic earth lay by itself, in the form of a coarse, harsh, and loosely conglutinated powder, of a yellowish-white colour.

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XIII.

## CHEMICAL EXAMINATION

OF

## HYACINTH.

ON giving the first information of the new simple earth discovered in the Jargon of Ceylon, I declared, at the same time, my earnest desire of seeing this discovery farther purfued, and confirmed by probatory refearches of able chemists. That wish, however, remained unfulfilled, with the exception of some few experiments made by Gmelin. It is probable that the few opportunities, which have hitherto occurred of obtaining jargon pebbles in a fufficient quantity, have prevented chemists from instituting a particular inquiry into their nature. They will, therefore, it is hoped, find pleafure in hearing, that the fame earth is likewife contained in another gem, the Hyacinth, which may be eafily obtained, and in fufficient quantity. This information will, perhaps, cause surprize, fince the analysis of the Hyacinth, published by Torb, Bergman, appears to have been long fince confirmed by its general reception. According to this, the Hyacinth is supposed to confist of,

# 196 XIII. Examination of Hyacinth.

40 . . . Argil,
25 . . . Silex,
20 . . . Lime, and
13 . . . Oxyd of iron.

Therefore, to obviate all doubts that may arise concerning the correctness of my present analysis, I declare before hand, that it is not merely the result of one single and superficial decomposition of the Hyacinth, but of several analyses of that gem, performed at different intervals of time, and in every respect complete.

The native country of the Hyacinth, which was the subject of the following experiments, is Ceylon.—Whether those species of stones, which in European countries, in Bohemia, Italy, and France, for instance, are indicated by this denomination, are true Hyacinths, I have not, as yet, been able to convince myself by any satisfactory proof.

I have found the specific gravity of the genuine Hyacinth for the most part to agree with that of the Jargon; that is, according to its varieties, from 4,545 to 4,620.

The detail of the experiments, which, with fome variations, I repeated with the Hyacinth, may be the less circumftantial, fince, in effential points, the same holds good with respect to this gem, as what I have stated in the second section of the preceding essay to belong to the Jargon, its analysis and its constituent parts.

a) One bundred grains of Hyacinth received, by levigation in the flint-mortar, an increase of weight of ½ grain; which shews that its hardness is not materially different from that of the jargon

- b) This pulverized hyacinth, digested with two ounces of nitro-muriatic acid, yielded, upon saturating the solution with pot-ash, a light-brown precipitate, of 3½ grains, when dried. Ammoniac, added to it, dissolved nothing; and it remained colourless. After the precipitate had been again separated from the volatile alkali, I put it into muriatic acid, which dissolved its ferruginous contents, leaving a white earth behind, which, when ignited, weighed ½ grain. The portion of iron, precipitated by caustic ammoniac from the muriatic solution, weighed ½ grain, when ignited, and became black and resplendent. I sufed it with a neutral phosphat, upon charcoal, in order to find whether it contained manganese; but no trace of it was perceptible.
- c) The above  $1\frac{1}{2}$  grains of earth (b) were now added again to the hyacinth, after treatment with acids. The stone was then subjected to red-heat, with fix times its quantity of caustic alkali, in the manner explained in the essay on the jargon of Ceylon; the ignited mass was again liquested with water; and the earth remaining after this process weighed 123 grains, when collected, edulcorated, and dried.
- d) The alkaline lixivium was then faturated with muriatic acid, and evaporated. At first it continued clear; but towards the end filiceous earth separated, the quantity of which, after ignition, amounted to 6 grains.
- e) Upon those 123 grains, previously well washed with water, I poured a sufficient quantity of muriatic acid; which, with the assistance of heat, dissolved nearly the whole, a trissing residue excepted. This muriatic solution, evaporated in a moderate heat to a fixth or eighth part, lost its sluidity, and formed a limpid gelatinous coagulum.

It was then covered with water, and exposed, with repeated agitation, to a digesting heat. By this management, the filiceous earth separated in slimy, intumesced grains, and weighed, after ignition,  $23\frac{1}{2}$  grains.

- f) The folution, thus freed from its filex, was now faturated with a boiling lye of mild alkali; and the precipitate was washed and dried in the air. This last weighed 114 grains, proving, upon every trial, to be jargonic earth. A fourth part of it, heated to redness, weighed 16½ grains; which make the whole amount to 66 grains.
- The above 6 grains (d), with the  $23\frac{1}{2}$  grains (e) in the whole  $29\frac{1}{2}$  grains of filiceous earth, were ignited with a quadruple weight of vegetable alkali. When this mass had been again softened with water, it left a residue, which I extracted by muriatic acid. From this muriatic solution, also, when saturated with pot-ash, jargonic earth fell down, weighing 4 grains after ignition. Hence, subtracting these, the quantity of siliceous earth is reduced to  $25\frac{1}{2}$  grains.

One hundred parts of hyacinth, therefore, have given

fargonia	g)	45	70
Subtract .	a) .		
Oxyd of iron .	b)	25	25
etien met en de la company de		Lofs	95,50
		Allegation should be	100

What

What I have already mentioned, when treating of the jargon of Ceylon, both with respect to the variation in the proportion of the silex, and the small quantity of iron still remaining, which may be separated by means of Prussian alkali, applies likewise to the hyacinth.

Hence, the jargon of Ceylon, and the hyacinth, should, in suture, be ranked in the series of natural bodies as two species; or, if it be preserved, as two genera, under one peculiar and distinct order of stones. But which of these two is entitled to preserved, in giving its name to the genus?—The jargon has, indeed, already obtained that distinction; but ought it not to be transferred to the hyacinth, being a gem much older, longer known, and more esteemed?—If so, the denomination hyacinth-earth should then be adopted, and substituted to that of circonia, or jargonia.

XIV.

## CHEMICAL EXAMINATION

OF THE SUPPOSED

# HUNGARIAN RED SHÖRL.

THE fossil, found at Boinik\*, in Hungary, and called red Shörl, is there dug up from a bed of quarz, stratished with shiftose mica. Its colour is a pale brownish-red. Its sigure is a column strongly surrowed, or channelled, lengthways, which, in my specimens, exhibits a rectangular parallelopipedon. The larger specimens which I posses are inch thick; but these shorts are commonly thinner, and form only needle-shaped crystals, the external surfaces of which are striated, and, as well as those of the fragments, strongly shining. Their cross fracture is soliated; the longitudinal fracture of a medium between the soliated and uneven, and in some parts of the minute conchoidal. The splinters of this sossil, and thin edges, are transparent, like the light-red silver-ore, which, in general, it very much

<sup>\*</sup> Born mentions Rhoniz as the place where it is found. See his Catalogue Meth. et Rais. de la Collect. d. Fossil. Tom. i.p. 168.

refembles when in fragments. It breaks into small acuteangular pieces, which, however, shew a very great hardness on trituration; and the colour of the powder is between the orange and brick-red. Its specific gravity I have found to be 4,180.

It was undoubtedly the oblong form, together with the striated, fluted surface of its crystals, which occasioned this fossil to be classed under the tribe of shorl: whereas other mineralogists think themselves entitled, from its colour and fracture, to reckon it a garnet.

But it will be made evident by the refults of the following analysis, that this mineral body belongs neither to the one nor to the other of those species of stones, nor at all to the class comprising the genera of earths and stones. On the contrary, it will appear that it consists of a peculiar, distinct, metallic substance\*.

#### A.

- a) I exposed a piece of this mineral, in a crucible made of clay, to the heat of the porcelain furnace. By this it suffered no change as to figure and lustre; but the colour passed into a deep brown-red.
- b) Another specimen, that was subjected to a porcelain heat in a charcoal-crucible, burst into angular grains; while

<sup>\*</sup> For the quantity of this rather scarce fossil, requisite to this analysis, I am indebted to the kindness of Count Wurben, of Vienna.

its colour changed to a faint light-brown, and scarcely any of its original lustre remained.

- c) When fused with an alkaline phosphat, upon charcoal, before the blow-pipe, no folution ensues. The globule acquires a pale reddish grey, and turns opake. A gentle pressure makes it fall asunder, in the form of fand.
- d) Melted borat of foda (borax) disfolves it, uniting with it to a clear vitreous bead of an hyacinthine red.
- e) If the powder of this fossil be fused in the silver spoon with foda, it gradually dissolves, and the globule becomes untransparent, and of a reddish white colour, after cooling.

B.

In order to examine the agency of acids on this mineral, when finely pulverized, I inferted feveral portions of it in four feparate phials, and poured upon one fulphuric, upon the other nitric, upon the third muriatic, and upon the last nitro-muriatic acid; subjecting them all to long digestion in a strong heat. No action ensued in either; for the fossil was again taken out of each acid without any alteration.

C.

Having blended one hundred grains of the fossil, finely levigated with four times its weight of caustic pot-ash, I exposed it to a red-heat for one hour. When removed from the fire, I softened it by water, super-saturated with muriatic acid, and subjected it to digestion. There seemed

but little of it dissolved, and the undissolved part lay at the bottom of the vessel, as a white, tenacious, and heavy earth. When the mixture was thrown upon the filter, in order to separate the sluid, it passed through the pores of the paper in the form of milk. For this reason, I put the whole again together into one mass, diluting it with a greater quantity of water; and the earth having subsided after 24 hours, the water was decanted, and the sediment dried in a warm temperature. By this management it again acquired a reddish colour.

This feemed to indicate that the cohesion of this short was not yet perfectly loosened. I therefore ignited it once more with 200 grains of the caustic salt, and again digested, with muriatic acid, the mass previously softened. Even in this case the mixture resembled milk, and continued several days in this state, without becoming clear. I diluted it then with more water, and made it boil: upon which the earth separated in detached, slocculent particles, which then admitted of being collected on the filter. But they adhered to it very firmly and clammily; which, upon exsiccation, rendered its separation difficult.

I instituted several preliminary experiments with that portion which could be collected; by which I learnt, that, in this instance, I was engaged with a peculiar metallic exyd.

# D.

I repeated the decomposition of the fossil with such a variation of the process, as to avoid the difficulty in separating and collecting the precipitate, which took place in the preceding attempts.

Two hundred grains of the fosfil, finely pulverized, and mingled with five times their quantity of carbonated alkali, were ignited in a porcelain-pot. The mixture entered into a thin fusion; but when poured out, it coagulated to a greyish-white, dense mass of acicular crystals, at the upper surface, and of a fibrous fracture. This I triturated and liquested in boiling water. A white precipitate soon substituted, from which the supernatant liquor was filtered off, and saturated with muriatic acid. By this management, a white, slimy earth fell down, that weighed eight grains after drying, and consisted of a mixture of argillaceous and siliceous earths.

The refiduum, washed, and deficcated in a gentle heat, appeared as a white loose earth, and weighed 328 grains.

#### E.

This white earth was subjected to a number of experiments; the results of which were, as follows.

#### I. Its relations to acids.

- a) It foon diffolved in dilute fulphuric acid, and afforded a clear folution, which, when exposed to the air, evaporated, leaving a white, turbid, paste-like substance behind it.
- b) Nitric acid likewise formed with it a limpid solution. By spontaneous evaporation, this acquired an oily consistence, and deposited minute transparent crystals, the primitive figure of which was an oblong rhomb, and seemed to change into an hexahedral plate, or table, by the truncation of its two opposite acute angular ends.

c) When the folution of this earth in muriatic acid was left to evaporate of itself, it thickened to a bright-yellow, clear, gelatinous substance, beneath which there shot a quantity of very small, clear, crystalline grains, of a cubical form.

In these acid solutions there remained between five and fix parts of siliceous earth in the hundred. However, a quantity of siliceous earth, to appearance still more conderable, was yet left behind, in combination with the white earth, and entered with it into the solutions. It is by this circumfrance that these solutions are reduced to a gelatinous coagulum, and that a more regular crystallization is impeded.

- 2. Relations of these solutions to the precipitating media.
- a) Carbonat of pot-ash precipitates the dissolved earth in a white, light, flocculent form.
  - b) Caustic ammoniae produces the same effect.
- c) Prussiat of pot-ash affords a large precipitate, mixed of grass-green and brown.
- d) Tinesure of galls, or gallic acid, throws down a brownred precipitate, of very confiderable bulk. If the folution
  has not been previously diluted with much water, it congeals like blood. Alkalis separate nothing from the decanted sluid. The precipitate, when collected, washed,
  and dried, has the appearance of Kerme's mineral (red sulphurated oxyd of antimony). When I exposed 15 grains of
  this powder to a weak heat, upon coals, in a small crucible, it
  immediately glimmered, and turned white. After this degree of ignition, it was found to weigh 6 grains.

## 206 XIV. Chemical Examination of the

- e) When combined with acid of arfenic, a white precipitate ensues.
  - f) The same is occasioned by phosphoric acid.
- g) Acid of tartar produces a white precipitate, but which, foon entirely re-diffolves.
  - b) The fame takes place upon the addition of oxalic acid.
- i) A fmall flick of tin was immerfed in a phial, full of a muriatic folution of the fosfil, and provided with a stopper. After some minutes a faint rose-colour shewed itself around the stick of tin, passing, at last, into a beautiful amethystine red.
- A) Another phial, capable of being closed with a stopper, was filled with this muriatic solution, but diluted with fix times the quantity of water; and into this I put a small stick of zinc. The solution at first changed to a violet, but afterwards to a deep indigo-blue. When placed in a warm temperature, in an uncovered dish, the solution gradually lost its colour, and deposited a white, bulky precipitate; which, when separated by siltration, and again dissolved in muriatic acid, retained the same properties as the earth did before the solution.
- I) But the muriatic folution, when combined with Hahneman's acidulous liquor, impregnated with fulphureous gas\*, remained unaltered.
- m) However, Beguin's fulphuret of ammoniae, added to that mixture, gave it a dirty, green colour, and produced a blueish-green precipitate. If the white earth, in the dry

<sup>\*</sup> Hahneman's Wine Proof. See Gren's Principles of Chemistry, vol. ii. page 253, note.—Transl.

ftate, be covered with this fluid, it is immediately tinged of a brownish-green.

# 3. Habitudes of the above-mentioned earth in the dry way.

- a) Fifty grains of the white earth, mentioned above, when ignited in a crucible, were afterwards found to weigh 38 grains. As long as it continued warm, it exhibited the yellow colour of fulphur; which, however, difappeared upon cooling. This earth, after ignition, is no longer acted on by acid menstrua.
- b) But if the earth be heated to redness upon charcoal, it first becomes reddish, and then of a slate-blue. By this treatment it also suffers into an ill-shaped globule, which, after refrigeration, presents a finely radiated surface. However, this melting is effected, perhaps, only by a small portion of alkali, which still adheres to the earth.
- c) The fame earth, when fused upon charcoal, with a neutral phosphat and borax, or with soda, in the small spoon, yields the same results as does the rough fossil, when treated with these sluxes. (A. c. d. e).
- d). This white earth, also, mixed and conveyed with a proper enamel-flux, upon porcelain, and baked, produced a pure straw-yellow colour, of a good body. This colour was likewise obtained by the raw mineral.
- e) At last I attempted to reduce it to the reguline state. For this purpose I blended 60 grains of the white earth, ignited, with 30 grains of pulverized colophony (the residue after the distillation of the etherial oil from turpentine), and caused this last to burn away by means of a gentle fire. No sooner had the stame ceased, than the earth appeared

peared again as white as before. It was next divided into two parts. The one half of it was mingled with 20 grains of pulverized white glass and 10 grains of calcined borax, and inclosed together in a crucible made of charcoal. The other half was introduced—alone—into the cavity of the charcoal-crucible, covered only with a mixture of glass and borax. Both crucibles, well secured, were then put into the porcelain-furnace; and both afforded the same product; which consisted of an irregularly sufed slag, or scoria, brownish at top, light-blueish-green below, and of a finely porose fracture, with some detached large air-holes, the interior sides of which seemed to be consusedly striated.

This fosfil, therefore, belongs to those metallic substances which appear to be incapable of being exhibited in the state of a sused metallic bead.

F.

The fum of these results surnishes several arguments, upon the strength of which I do not scruple to consider the red short, as it has been hitherto called, of Boinik in Hungary, as a natural metallic oxyd. The phenomena, upon which I ground my conclusion, are: That the white earth, subjected to ignition, becomes yellow, reddish, and, in contact with charcoal, blueish; that it produces a yellow enamel colour; that it is precipitated from its solutions in acids, by Prussian alkali, gallic acid, and alkaline sulphuret; that, when treated in the humid way with tin and zinc, it is recovered in dark slakes, the solution then acquiring a red and blue colour; and, lassly, that it shews a very strong tendency to combine with oxygen. It is on account of this last property, that the crude sossil, as being sully saturated

rated with that acidifying principle, is infoluble in acids, and is rendered capable of folution only when, by ignition with an alkali, it is deprived of a part of its oxygen. For this reason, likewise, when I ignited the rough fosfil, in a subfequent analytical experiment, with only two parts of vegetable alkali, the earth obtained did not prove so white and loose as that sused with sive or six parts. It also dissolved but imperfectly, in muriatic acid, and not at all in the sulphuric and nitric.

To these facts must be added the phenomenon, that the muriatic solution of that substance became changed into a blue tincture by zinc; but when decanted, and exposed to open air, in a warm place, it again lost its colour, by imbibing oxygen, and deposited a white earth.

Another phenomenon, probably the confequence of fuper-faturation with oxygen, took place when I endeavoured to promote the crystallization of a complete muriatic solution, by evaporating it in a fand-bath. This was, that the liquor, which had before been perfectly clear, acquired a turbidness and resemblance to milk, by the heat: nor could it any more be rendered a limpid solution by the fresh addition of acid.

It is fufficiently shewn, by several of its properties, that this metallic substance does not belong to any of those at present known, but rather deserves to be reputed a new, peculiar genus of metals. Among these, the copious brown-red precipitate, produced by the gallic acid, surnishes an easy test and specific means of distinguishing it from other metals.

We are yet to give this new metallic substance an appropriate name.

When

## 210 XIV. Chemical Examination, &c.

Whenever no name can be found for a new fossil which indicates its peculiar and characteristic properties (in which situation I find myself at present), I think it best to choose such a denomination as means nothing of itself, and thus can give no rise to any erroneous ideas. In consequence of this, as I did in the case of the Uranium, I shall borrow the name for this metallic substance from mythology, and in particular from the Titans, the first sons of the earth. I therefore call this new metallic genus TITANIUM\*; of which this Titanium, mineralized by oxygen, or oxyd of Titanium, is, indeed the first, but perhaps not the only species, as is made probable by the following essay.

<sup>\*</sup> The metal called Menachanite, by Kirwan, Mineralogy, vol. II. part iv. chap. 21, is the same, or analogous to Klaproth's Titanium. See Gren's Principles of Modern Chemistry, 1800. Lond. \$vo. vol. ii. page 425.—Trans.

XV.

## CHEMICAL EXAMINATION

OF

A NEW FOSSIL, from the Dictrict of Passau.

AMONG the various and hitherto unknown crystallizations of some fossils, which professor Hunger has discovered in the bishopric of Passau, and whose external characters he has described\*, there is one particularly remarkable, as even its constituent parts are not yet known.

The crystals of that fossil are small quadrangular rhombic columns, of a reddish, greyish, and blackish-brown colour. Their size varies from  $\frac{1}{48}$  to  $\frac{1}{4}$  of an inch. Their lateral facets are joined alternately, under angles from 135 o 45 degrees. Both their ends form very sharp angles; and the inclining sides issue from the obtuse lateral edge. Their surface is smooth and resplendent. Their cross-fracture is dim, but their longitudinal fracture exhibits a middling lustre. The smallest crystals of that mineral, and sometimes its edges, are transparent; but it is often totally

<sup>\*</sup> Beobachtungen und Entdeckungen aus der Naturkunde. 5ter. Band, 2tes St. Berlin, 1794.

# 212 XV. Of the new Fossit from Passau.

opake. Though its crystals are brittle, and easily friable, yet they shew a considerable hardness when grinding, and then afford a whitish-grey powder.

It is met with in several places in the neighbourhood of Passau, and also, though seldom, in the Innviertel, in Bavaria. Those crystals almost always occur dispersed in a species of coarsely-grained stony matter, the predominant part of which consists of a greyish, or greenish-white selfpar, mingled with hornblende, quarz, mica, semi-indurated steatites, of which sometimes all together are united with it; and, at other times, only one or two\*.

#### A

- a) The specific gravity of this fossil is 3,510.
- b) Its crystals, when ignited upon charcoal, before the blow-pipe, suffered no remarkable change, except that here and there very minute bubbles were produced on their surface.
- c) Exposed in a crucible made of clay, to the most intense heat of the porcelain furnace, they likewise continued without farther alteration; but in the charcoal crucible they concreted into a scoria, half-fused, black, opake, somewhat porous, and of a moderate lustre.
- d) On being treated in the humid way with muriatic acid, and repeatedly digested with it, one third part of their

<sup>\*</sup> Professor Hunger had the kindness to send me some of his crystals, which had been collected with great trouble, in quantity sufficient for investigating the constituent parts of this mineral.

weight was diffolved. This folution had a ffraw-yellow colour; and the addition of caustic ammoniac, in excess, afforded a precipitate, whose appearance and consistence refembled paste made of starch; but which, when dried and ground, exhibited a loose, yellowish powder. The remaining stuid contained, also, some calcareous earth, which I precipitated from it by carbonat of soda.

What remained, after the extraction by means of the acid, I subjected to ignition, together with four times its weight of mild alkali, prepared from tartar. It was next faturated to excess, and digested with muriatic acid, and filtered. Siliceous earth was then left behind on the paper. Caustic ammoniac threw down from this solution a precipitate perfectly resembling the foregoing; to which, therefore, it was added.

The external appearance of this precipitate led me to fuspect in it the presence of aluminous earth, impregnated with iron. However, it was not found to be so upon farther examination: for, after I had again dissolved it in muriatic acid, and once more precipitated it from this last solution, the caustic alkaline lye, with which the precipitate was digested after edulcoration (while yet in a pulpy state), would dissolve only a very trisling portion of it.

I then fused, with glass of borax, a small portion of the precipitate, again washed and dried; and obtained a small topaz-yellow glass-globule. Another portion, sused with phosphoric salt, produced one of a pale amethystine colour.

Again; another small portion of it, which was dissolved in dilute sulphuric acid, shewed no sensible taste of alum, and dried to a whitish mass, without shooting into crystals.

# 214 XV. Of the new Fossil from Passau.

The remainder of that precipitate I re-diffolved in muriatic acid, and treated the foliution with the following tests, or re-agents.

Prussian alkali produced a dark-green precipitate.

Gallic acid afforded a precipitate of a lively brown-red colour, but passing into a pale yellow-red, as it cooled.

A little flick of zinc was immerfed into that part of the folution which yet remained; and a fubtle greenish-black slime was observed settling around it, at the same time that the solution itself assumed the colour of amethyst. The fluid again lost that colour after some days, and white, slocculent particles, mingled with the slime, fell down.

#### B.

Guided by these previous observations, I proceeded to the following new experiment.

- a) One hundred grains, finely ground, were subjected, for one hour, to ignition, with a quadruple weight of caustic alkali. The mass, softened by water, yielded a weak grassgreen solution; but this colour disappeared again, as soon as more water was added a-fresh. Upon digesting it with muriatic acid, added to excess, and subsequent siltration, siliceous earth was left behind, which, when ignited, amounted to 12 grains.
- b) The dissolved part was next precipitated, by means of carbonated pot-ash. Upon the dried precipitate, I added a new portion of muriatic acid, and a notable smell of oxygenated muriatic acid gas was emitted. During the

digestion, there again separated some filiceous earth, the quantity of which, after ignition, amounted to 23 grains.

- c) At this time, I combined the folution with caustic am moniac. The yellowish-white precipitate, obtained thereby, weighed 62 grains, upon deficcation. One fourth part of it, heated to redness, was found to weigh 8½ grains; whence its whole quantity makes 33 grains.
- d) To the remaining fluid, mild vegetable alkali has been added, at a boiling heat. It thereby yielded calcareous earth, to the amount of 33 grains, when ignited.

#### C.

Having, in this manner, discovered the proportion of the conflituent parts, I next examined, a second time, the precipitate obtained (B. c.).

- a) When ignited alone upon charcoal, it turned brown-ifh-yellow, and, at last, blackish.
- b) By fufing it with borax, a transparent globule of an hyacinthine colour was produced.
- c) Phosphoric falt did not diffolve it, but only divided it minutely. If any trace of manganese had remained in this precipitate, it would have manifested itself by a faint amethyst-colour, with which it tinges phosphoric glass.
- d) The portion diffolved in acids was thrown down by tincture, or acid of galls, of a lively, brown-red hue.

e) Prus-

# 216 XV. Of the new Fossil from Passau.

- e) Prushat of pot-ash afforded with it a green precipitate, inclining to brown, and thereby resembling sap-green. This, however, when dried, appeared again with its original green colour. The liquor, separated from it by filtration, was not altered by re-agents.
- f) The addition of fulphuret of ammoniac, prepared after Beguin's manner, produced a flocculent precipitate, of a dark muddy-green.
  - g) Phosphoric acid, as well as
    - b) The acid of arsenic, produced a white precipitate.
- i) Lastly, this precipitate, when combined with a proper quantity of enamel-flux (glass-paste), and thus laid upon porcelain, and fused, gave to its surface a yellow colour, verging to brown.

Therefore, fince these results not only indicate, in an unquestionable manner, the metallic nature of this conflituent part, but, moreover, since its habitudes, upon the whole, very much correspond with those of the Titanium (the new metallic substance treated of in the last essay); and, finally, since the trisling varieties in the various phenomena seem to originate merely from accidental circumstances, I do not hesitate to reckon this constituent part as an oxyd of Titanium.

And, in order that this foffil itself may be distinguished by a particular name, as a distinct species, the denomination Titanite, derivated from the above new metallic substance, does not seem to be altogether improper. Its constituent parts have been found to exist in it in the following proportions:

# XV. Of the new Fosfil from Passan. 217

Silex B. a) 12 } b) 23 } .	•	35	
Lime d)			
Oxyd of Titanium c)			
Manganese, a slight trace.			

IOI

Now, what place ought to be affigned, in the mineralogical system, to this new soffil? Since mineralogists are not yet agreed as to the principles, according to which the system of mineralogy should be arranged, those who direct their principal regard to the specifical constituent part, will readily class the Titanite as a second species of the Titanium genus. Such, on the contrary, as insist more strictly on the predominant part, with regard to quantity, will, perhaps, decide for its insertion under the head siliceous genus.

[ 218 ]

XVI.

## EXAMINATION

OF THE SUPPOSED

## MOLYBDENOUS SILVER.

A FEW years ago a metallic fossil was met with at Deutsch-Pilsen, in the Comitatus Hontensis, in Hungary, which by Born has been introduced as a new species of silver-ores.—He gives the following description of it\*.

## ARGENT MOLYBDIQUE.

Silver combined with fulphurated Molybdena.

"This combination or alloy of filver with fulphurated molybdena has been till now unknown. It is no where

" found, except at Deutsch-Pilsen in Hungary, where it

" roas met with in infulated kidney-form nodules (rognons), from one to two inches in thickness, enveloped in a common

" from one to two inches in thickness, enveloped in a common grey clay. These nodules separate in pretty large and

" Shining laminas, that admit of a new division into smaller

amellas, perfestly refembing sulphurated molybdena, and

" staining the paper with grey traces. By cupelling this "supplied and molybdena, there are obtained 23 marcs of sil-

ce ver (184 oz.), from one centner."

As, from the peculiar fearcity of this mineral, few chemifts only may have opportunity of examining it, I undertook this task the more readily: and I found by these refearches, that it contains neither silver, nor melybdena, and that it consists of bismuth, mineralized by sulphur\*.

<sup>\*</sup> See his Catalogue de la Collection des Fossiles de Mile de Raab. Tom. II. p. 419.

#### A.

- a) If this ore be tried per se upon charcoal, with the assistance of the blow-pipe, it runs into a globule, as soon as it comes in contact with the point of the slame. That globule may be gradually blown off by means of the bellows, in which case it gives out a metallic vapour, which in part settles on the coal, of a yellow colour. But if borax, or a neutral phosphat, be added, it separates from the melting saline pearl, and leaves the latter colourless behind it.
- 2) Twenty-five docimaftic pounds of this ore † subjected to cupellation under the mussle, with four times their weight of lead, left behind them a globule of silver, only visible by the microscope; but this, undoubtedly, must have been furnished by the lead.

#### B.

a) Upon fifty grains of the triturated ore I poured moderately strong nitric acid. It was immediately attacked and dissolved by it, with extrication of red vapours; and the residuum consisted of  $2\frac{I}{2}$  grains of sulphur.

<sup>\*</sup> That I may not be suspected of having bestowed my labour not upon the genuine argent molybdique of Born, I here declare, that the specimen which I examined was a fragment of the very individual piece, of which Born has described the above external characters.

<sup>†</sup> About 24½ drachms Troy-weight. The German docimaftic centner, or one drachm, is equal to 72 French grains of the former poid de marc, which correspond to 59,0677 English grains Troy. Transl.

- b) I afterwards diluted the folution with a large quantity of water; upon which the mixture inftantaneously affumed the appearance of milk, and deposited a fine, white, and heavy precipitate, consisting of pure oxyd of bismuth.
- c) The fluid feparated by filtration was mixed with muriat of foda. It continued at first perfectly clear, but gradually it was rendered somewhat milky; and at the bottom there collected a subtle, ponderous precipitate, the dazzling whiteness of which suffered not the least change by the day's light, and was likewise merely oxyd of bismuth. Had there existed in it any trace of muriated silver, however small, it would have discovered itself by tarnishing the white colour of that precipitate, on exposure to the light of the day.

Consequently, one hundred parts of this ore contain:

Bismuth				95
Sulphur				
				100

From this small proportion of sulphur, it seems that the bismuth is but impersectly mineralized; hence that ore nearly approaches to native bismuth. And probably on this circumstance depend its whiter colour, and brighter lustre, which so much resembles that of silver recently polished; and by which it is distinguished, in external character, from the sulphurated bismuth of Riddarhyttan, in Westmanland, which is more of a lead-grey colour.

#### XVII.

## EXAMINATION

OF THE

# NATIVE ALUMINOUS EARTH FROM SCHEMNITZ.

IN the pit called Stephani-Schacht, at Schemnitz, in Hungary, an earth was lately dug up, which is there reckoned to be aluminous earth, naturally quite pure and free from filex. It is as white as fnow, light, crumbling, very friable; it stains but moderately, and adheres to the tongue\*.

I put this earth to the trial in the following manner:

- a) One hundred grains of it were exposed to a strong red heat for one hour in a covered crucible. After refrigeration, I observed in it a loss of weight of 42 grains; which, it is obvious, was only the weight of the particles of water driven out by the fire. No alteration was effected by this in the exterior appearance of the earth; except that the pieces were made a little rifty, and diminished in fize.
- b) Another hundred grains of this earth were gradually conveyed into dilute fulphuric acid. They diffolved in it without effervescence, yet accompanied by an observable disengagement of caloric. The solution proved perfectly limpid; but upon evaporation it formed a clear and transparent coagulum, the surface of which, after a few days, appeared to be covered with a quantity of solitary, pyramidal, crystalline shoots. The mass was next drenched

<sup>\*</sup> A fuller description of it has been given by Fichtel, in his Mineralogische Aufsätze. Vienna, 1794. page 170.

222 XVII. Of the Native Alumine from Schemnitz. and digested with an abundance of water; and then filiceous earth separated, weighing 14 grains, when collected by filtering, and ignited.

c) When the folution, thus freed from the filex, had been combined with the requifite portion of pot-ash, and crystallized, it afforded pure alum; from which the aluminous earth was afterwards precipitated by means of pot-ash, and purified in the manner frequently mentioned.

Hence the discovered constituent parts of this earthy foffil amount to:

Ignited Alumine c) .				45	
Silex b) .					
Aqueous particles lost by ignition	100	0,		42	
A simulate And morson out at their A				IOI	

The chemical knowledge of this earth is chiefly remarkable on this account, that hitherto, with the exception of fome gems, no other mineral fubstance has been known, which consists of alumine and filex in such proportions that the quantity of the first so far exceeds the second. Whereas in the species of clay, strictly so called, for instance in the porcelain clay, the alumine which they contain is usually but equal to a fourth, or at most a third part of the silex. Whence it follows, that in the above fossil, the two constituent parts of clay are to each other precisely in the inverse ratio of that, in which they commonly exist in clay.

From the above refults it is likewife evident, that this earth is by no means absolutely pure alumine, as has been supposed. As the only instance of alumine of that degree of purity, therefore, we must still consider that earth which is found at Glaucha, near Halle, on the river Saale, in single kidney-form pieces; although its true origin yet remains a problem to be solved.

XVIII.

[ 223 ]

#### XVIII.

## CHEMICAL RESEARCHES

INTO

## STRONTIANITE,

COMPARED WITH

## WITHERITE\*.

SEVERAL properties, which Strontianite has in common with those of Witherite, seemed to justify its being taken, when first discovered, for a species of the native carbonat of barytes. However, by the circumstance of paper, dipped in a nitric solution of strontianite and dried, burning with a red slame, I was induced to conjecture, that this fossil might, perhaps, be distinguished from witherite by other properties. This supposition was strongly supported by the result of the chemical examinations instituted by Sulzer upon this substance, as well as by the experiments which Blumenbach has made upon animals.

It was probably the difficulty of obtaining strontianite in sufficient quantity, that has prevented the repetition and confirmation of those experiments; in consequence of this, the present additional essay, tending to procure a more accurate knowledge of it, may be deemed not superstuous.

But in order the better to compare the properties and chemical relations or habitudes of strontianite compared

1 B. page 99.

<sup>\*</sup> Chemische Annalen, 1793. 2 B. page 189. and ditto, 1794.

# 224 XVIII. Researches into Strontiantie

with those of witherite, I have thought it proper to place together the results of an examination into each.

Both these fossils belong to those products of nature, that have been discovered only within the last ten years.

a) The place at which the *ftrontianite* was found the first time is *Strontian*, in *Scotland*; where this fossil breaks in a vein of lead, together with ponderous spar (sulphat of barytes), in a mountain chiefly consisting of gneis\*. It is found massive, in oblong coarsely sibrous pieces, accumulated in bundles. It is of a light green, a little transparent, shining, and moderately hard.

Its specific gravity I found to be 3,675.

According to the experiments which Blumenbach has made with regard to the effects of strontianite upon animal life, it was found to possess nothing of the deleterious properties of witherite; as the former was eaten by animals without injury.

b) The witherite, or native carbonat of barytes, is dug in the lead-mines at Anglezark, in Lancashire; where, together with the foliated sparry barytes, it forms the gangue, or earthy matter, serving as a matrix to the galena. The miners and inhabitants of that vicinity have been long ago acquainted with this mineral, denominated by them Ratssfone, as containing a poison fatal to animals. The reason, why the geognostic situation and the true native place of witherite (salsely stated to be Alston-Moor, in Cumberland)

<sup>\*</sup> This mountain is faid by others to be granitic; however, the stony matter adhering to my specimens of strontianite proves it rather to be gneifs.

continued for some time misunderstood, was the concealment practised by the miners of that place, who, from its weight, suspected it to contain some noble metal; and perhaps also to the base interestedness of the usurious dealers in fossils.

The colour of witherite is grey-white. It usually occurs in confiderable masses, and only occasionally in fix-sided prisms, terminated by hexahedral pyramids. Thin fragments of it transmit the light. Its longitudinal fracture is glossy, and feebly striated; but its cross-fracture is only glittering and uneven. Its hardness is but middling; and its specific gravity is 4,300, and therefore more considerable than that of strontianite.

A fecond place at prefent known, where native carbonat of barytes occurs, is the Schlangenberg, in Siberia. There it is met with of a grey-white colour, in the form of a stalactical incrustration, resembling chalcedony.

## FIRST EXPERIMENT.

a) One hundred grains of ftrontianite in coarse fragments, and put into a porcelain-vessel, were ignited during the space of two hours in a wind-furnace. Their figure was not sensibly altered by this; but their bright-green colour, their lustre, and transparency, were destroyed. On weighing them, while yet hot, I observed a loss of weight of no more than half a grain; and this loss seems to be merely that of the moisture expelled.

This experiment I repeated with another 100 grains; but exposing them for five hours to a fire of such intensity, as to be capable of converting white marble into quick-lime, in but half that time. By this much stronger and more lasting

red\_

red-heat, they loft 61 grains of weight. Hence, subtracting the above half grain, which, on account of the previous ignition, may be deemed watery parts, it follows, that fix grains of carbonic acid were thus driven out. This burnt strontianite gave a caustic taste. I triturated and boiled it with four ounces of water, which I separated again by filtration. The taste of this much resembled that of fresh and strong lime-water. Two ounces of it were put aside in a flightly covered glass. After a few minutes it was already covered with a white earthy pellicle; which continued to form anew for feveral days, as foon as the preceding had been broken by agitation, and thereby caused to fall down in thin lamellas. When no more was produced, I collected these lamellas; and they weighed seven grains after drying. Diffolved vegetable alkali was then added to a part of the water, which had been boiled with burnt frontianite. The mixture became milky, and deposited carbonated frontian-earth in a fine pulverulent state. Into another part of that water I instilled sulphuric acid, whereby a flocculent fediment of fulphat of strontian-earth immediately precipitated. A third portion of this water was mixed with corrofive muriat of mercury (corrofive fublimate), which was immediately decomposed; fo that the metallic oxyd exhibited at first a brown-red, and, upon farther affusion of water, an orange-yellow-colour.

Therefore, notwithstanding the violent ignition which it had suffained, only a small part of strontianite had been deprived of its carbonic acid by this experiment; while the other portion still effervesced with acids as strongly as the fresh unburnt strontianite.

b) For a comparative experiment, I subjected one hundred grains of witherite in a porcelain-crucible to the same degree of red-heat, and for the same time of five hours.

Its form was no otherwise changed thereby, than that its bulk became somewhat increased; but its transparency was entirely gone; and its colour then inclined to a blueish milk-white. Nor was its weight found to be considerably diminished, by weighing it while yet hot. The water, that had been boiled with it, as in the foregoing experiment, could not be distinguished from pure water, neither by the taste, nor by re-agents. Corrosive sublimate dissolved in it without turbidness; and it likewise continued persectly limpid, on dropping sulphuric acid into it. The ignited witherite also yielded, on the subsequent affusion of muriatic acid, the same quantity of carbonic acid gas, which is extricated from it, when in the crude state.

## SECOND EXPERIMENT.

- a) I caused a piece of strontianite, of about half an ounce in weight, to be exposed, in a clay-crucible, to the most vehement heat of the porcelain-furnace. When the vessel had been returned to me, the strontianite was found to have attacked and dissolved the clayey mass of the crucible, and to have run with it into a clear chrysolite-green, very hard, and dense glass.
- b) The piece of witherite, which, by way of reciprocal experiment, had been exposed in the same manner to the same fire, and under the same circumstances, had likewise strongly acted on the crucible, and was converted into a hard, greenish glass, which, however, was not perfectly compact, but held some air-bubbles.

I repeated this experiment, but with this variation, that I weighed accurately 100 grains of each of these two fos-fils; and I also exactly noted the weight of the clay-cruci-

bles, which had previously sustained a violent ignition. By this vitrification the *firontianite* lost 30, and the witherite 22 grains; which loss of weight exactly agrees with the proportion of carbonic acid contained in each of those minerals, as will appear from the sequel.

## THIRD EXPERIMENT.

a) In order to afcertain the habitudes of strontianite, when exposed to the degree of heat requisite to the baking of porcelain, and debarred from immediate contact with the crucible, I inferted one piece of it, weighing 160 grains, into a cavity made in a compact piece of charcoal, and closed that cavity with a stopper, likewise made of charcoal. This piece of charcoal was then fecured in a well luted melting-pot, which I ordered to be put upon that part of the porcelain furnace, where the fire acts in the most intense degree. Upon opening the pot, which was brought to me from the furnace while yet warm, I found the outfide of the coal in part confumed\*, and hence leffened in its volume; but the middle and inner part was not in the least impaired. The strontianite which had been inclosed in it and burned, re-appeared in its former shape, without any mark of fusion; but with some diminution of its brightness. Its hardness seemed to have increased, rather than decreased, and the colour was outwardly changed to a grey. The loss of weight amounted to 491 grains, making 31 in the hundred; and by this it appears, that the strontianite

<sup>\*</sup> This phenomenon I have always observed, when employing a fimilar apparatus. The pores of the crucible are probably more opened by the vehemence of the heat; so that some consumption of the coal may take place on the outside.

had now been entirely deprived, both of its flight portion of water, and likewise of all its carbonic acid; as will be confirmed by the succeeding experiments.

When it had been reduced to powder, and twice boiled with water (one pound of the fluid each time), it entirely diffolved in it; leaving only an inconfiderable refidue, which, befides fome adhering coal-dust, chiefly confisted of lamellas of carbonated strontian, which was rapidly regenerated.

In the first of these decoctions, which immediately after filtration had been preserved in a stopped glass bottle, there appeared crystals in half an hour's time, which visibly increased, and formed an exceedingly beautiful group. These crystals were clear and transparent, of a needle-shaped figure, and aggregated in filiform, knit, or interwoven planes. The whole of them bore resemblance to the crystals of muriated ammoniac: or rather, considering the mostly upright and cellularly implicated facets, which are formed by the accumulation of plumose crystals, it resembles the native filver of Potosi, dendritically crystallized in large laminas.

However, this crystallization of calcined strontian-earth in simple water, without the access of other extraneous substances, is on its own account highly remarkable; even without noticing the beauty of its crystals. This phenomenon is entirely new, and the first instance of an artificial crystallization of a simple earth in mere water.

The fecond decoction of the burned strontianite, that was kept in another glass, likewise afforded, after a few days, some solitary crystals. These, however, had not the plu-

mose appearance of the foregoing, but were minute, oblong, quadrangular plates, sharpened on the edges.

The water decanted, proved still of a strong caustic tafte, and deposited carbonat of strontian, when carbonated alkali had been dropped into it. The cryftals themselves affected the tongue with the like corrofive taffe. By expofure to air, they turned opake and milk-white. A part of them, immersed in muriatic acid, dissolved in it; yet no air at all was developed; and at the same moment I observed acicular crystals of muriated strontian-earth shooting in the folution.

By treating witherite, on feveral repeated experiments, in crucibles formed of charcoal, for the purpose of depriving it entirely of its carbonic acid, I could never completely fucceed. That fosfil penetrated, and in some manner confumed the fubstance of the charcoal; and it was again found at the bottom of the outer clay-crucible, in a state of femi-fusion.

# FOURTH EXPERIMENT.

a) As, in these experiments, I had given the preference to muriatic acid, I first endeavoured to ascertain what quantity of it would be required to dissolve a certain portion of strontianite. With this view I mixed 100 grains of muriatic acid, of 1,140 specific gravity, with 50 grains of water, and introduced into this menftruum pure fragments of strontianite, weighing, in the whole, 62½ grains. After the acid had been fully faturated with it, without the affiftance of heat, there remained feven grains; hence 551 grains were dissolved and spent in the saturation of the acid. The action of the acid was vigorous, and the folution proceeded with a pretty

pretty strong effervescence. It was necessary to weaken the muriatic acid with half its quantity of water, because, when concentrated and alone, it shews but a weak operation.

Guided by this experiment, I took a quantity of muriatic acid sufficient to dissolve 100 grains of strontianite, and having diluted it with half its quantity of water, I put it upon the balance, and equipoised it on the other scale. These 100 grains of strontianite were then gradually conveyed into the menstruum, and thus the weight of the carbonic acid, disengaged, was found to be 30 grains.

Therefore, strontianite contains, in an hundred parts,

Strontian earth		
Water		-
the contract and beautiful and		100

b) To find in the comparative experiment, which I intended to make with witherite, the proportion of muriatic acid requisite to its solution and saturation, I prepared a mixture of 100 grains of muriatic acid with 200 of water; this degree of dilution being necessary, to render that acid capable of acting with full energy upon that mineral, and producing a clear solution. Into this mixture were then put 76 grains of witherite, in coarse pieces. The saturation of the acid was accompanied by a strong effervescence, and only three grains remained undissolved. One hundred grains of muriatic acid, therefore, required 73 grains of witherite, to be completely saturated; and, consequently, 17½ grains more of it than of strontianite.

# 232 XVIII. Refearches into Strontianite

In consequence of this proportion of muriatic acid to witherite, I now introduced 100 grains of this fossil into a sufficient quantity of that menstruum, which also I previously brought to an equilibrium upon the balance. When its solution was accomplished, the quantity of carbonic acid gas escaped amounted to 22 grains.

Hence, in hundred parts of witherite are contained,

Barytes			78
Carbonic	acid		22

100

#### FIFTH EXPERIMENT.

a) If the muriatic folution of ftrontianite be in part evaporated by a low heat, the middle, or earthy falt, will shoot in it into fine, longish, needle-shaped, but often, likewise, into larger prismatic crystals, which continue perfectly dry in the air, but readily dissolve in water.

If, upon these crystals, a sufficient quantity of ardent spirit, not too much dephlegmated, be poured, and put in a warm place, they are dissolved by it. The alkohol acquires, by them, the property of burning with a pleasing carmine-red slame, if printing-paper, cotton, and such loose bodies are moistened with it, and set on fire.

b) The muriatic folution of witherite, on the contrary, yields oblong hexagonal tables of a much more confiderable specific gravity; and likewise these crystals require a greater quantity of water to be dissolved than the others. Their solution, in weak spirit of wine, when set on fire, does not

exhibit the least trace of the red colour in the slame, by which that of strontianite is so remarkable. The ardent spirit burns, in this case, only with a yellowish-white slame.

#### SIXTH EXPERIMENT.

- a) The folution of *firontianite*, in nitric acid, is likewise easily effected. Out of 100 grains of the fosfil employed, 30 grains of carbonic acid gas were disengaged, as took place in the fourth experiment, by means of the muriatic acid. The nitrat of strontian, which is afforded by this folution, when brought within a smaller compass, by a flow evaporation, forms crystals, which are clear and permanent in the air, the fundamental figure of which seems to be the double quadrilateral pyramid (octahedron), with its usual variations.
- b) Nitric acid, employed for the folution of witherite, must be more liberally diluted with water, to prevent the too rapid formation of the crystals, which would otherwise take place. These, likewise, seem to be nearly octahedrons; they are, however, less distinct, and, in part, more of a tabular figure. They are, besides, distinguished from those of strontianite, by being less clear, and by their dull and opake appearance.

# SEVENTH EXPERIMENT.

a) By acetic acid ftrontianite is acted upon with little energy. I boiled vinegar, distilled and concentrated by freezing, upon finely ground strontianite, and gently evaporated the liquor filtered off from the undissolved residue. It afforded small and clear crystals, that did not deliquesce in the air, and the figure of which appears to consist of thin rhombic tables.

b) An acetic folution of witherite, prepared in the fame manner, affumed, at a raifed temperature, a tenacious confishence, and congealed upon cooling into a mass, resembling zeolite of the fine fibrous texture. Another solution of this kind, which I left to evaporate spontaneously in a shallow dish under free access of air, I observed to have crystallized in recumbent, very beautiful, ramified dendritic sigures of a milk-white colour; or, strictly speaking, it dried in that form. When this acetite of barytes had been redissolved in water, it then shot into regular and permanent crystals, forming long, thin, quadrilateral columns, obliquely truncated at their ends.

### EIGHTH EXPERIMENT.

a) Upon 60 grains of pulverized strontianite, introduced in a retort, I poured, by degrees, two ounces of concentrated sulphuric acid. The first portion that was affused caused a great frothing. The contents of the retort were then brought to boiling in a sand-heat. After cooling, the earth was found entirely dissolved, and the solution colourless. But it is again decomposed, as soon as any water is added. If only a few drops of water are instilled into it, it coagulates, and becomes milk-white. One single drop of this solution, thrown into sour ounces of water, renders this last turbid, and sulphated strontian-earth salls down.

The concentrated folution afforded, after fome days, fmall, bundled, and stellated crystallizations, the radii of which, as it seemed, were formed by minute quadrangular columns.

b) In like manner, 60 grains of witherite were combined with two ounces of strong sulphuric acid. A great effervescence ensued; and, with the affistance of boiling heat, a complete solution, as clear as water, was likewise, in this case,

case, produced. Some days after, the greatest part of this solution formed a crystalline mass, of very tender fibres. This solution was also immediately decomposed by the admixture of water, and sulphat of barytes precipitated.

### NINTH EXPERIMENT.

- a) I decomposed a solution of 100 grains of firontianite in muriatic acid, previously diluted with sufficient water, by means of mild vegetable alkali. The earth again took up from the precipitating medium that quantity of carbonic acid, of which it was deprived during its solution in the muriatic acid. When edulcorated and dried, it again appeared with its former weight of 100 grains.
- b) Witherite exhibits, the very same habitude in this point. From 100 grains of it, dissolved in that acid, and afterwards precipitated by carbonat of pot-ash, I likewise recovered 100 grains.

### TENTH EXPERIMENT.

It is, however, to be observed, that in these combinations of the respective earths of the strontianite and witherite with carbonic acid, made by art, this last constituent part is not so obstinately retained by them in a read-heat, as it is when both exist in their natural state.

a) For, when I exposed 100 grains of precipitated strontian-earth to intense red-heat during two hours, when upon this I boiled it in two ounces of water, and triturated two grains of corrosive sublimate, with the water siltered off from that decoction, the mercurial oxyd would not dissolve in it, but separated of a yellow-brown colour.

### 236 XVIII. Refearches into Strontianite

The lofs of weight, sustained by the ignited strontianearth, I could not determine with certainty, part of it having united with the body of the crucible. But the diminution of weight cannot have been of great importance; since the torresied earth still vehemently effervesced with acids.

b) Those 100 grains of earth that had been precipitated from the solution of witherite, and were ignited in the same manner, adhered to the crucible with still greater force. The water, with which that earth was boiled after its ignition, nearly in the same manner (a) precipitated the metallic oxyd from the sublimed corrosive muriat of mercury. Likewise the solution of the precipitated earth in an acid, when poured upon it, was still attended with effervescence.

# ELEVENTH EXPERIMENT.

Neither the folution of firentian earth, nor that of witherite, is rendered turbid in the least degree, or otherwise altered by caustic ammoniac, even when affused in great excess. But as soon as the slightest portion of an alkaline carbonat is afterwards superadded, an immediate precipitation takes place.

# TWELFTH EXPERIMENT.

a) Into a muriatic folution of 100 grains of ftrontianite I dropped concentrated fulphuric acid, adding it, by degrees, and till no more precipitate fell down. This, when duly washed, and desiccated in the air, amounted to 114 grains. Of this sulphat of strontian-earth I digested 40 grains, in a boiling heat, with eight ounces of water. The undissolved residue, collected after cooling and dried, was found to weigh  $37\frac{1}{2}$  grains. Therefore,  $2\frac{1}{2}$  grains were dissolved by

eight ounces of water, which folution, upon the addition of carbonated alkali, yielded a tender precipitate.

b) One hundred grains of witherite diffolyed in muriatic acid, and precipitated by the fulphuric, furnished 120½ grains of fulphat of barytes, after being washed and dried in the air.

It is, then, evident, by the refults of these experiments, that there subfifts an absolute and natural difference between the earth of strontianite and that of witherite, or of barytes in general. For, although both these species of earth seem to be nearly of the same nature, with respect to their relations to the fulphuric acid, as well as to the force with which they retain the carbonic acid in the fire; nevertheless many more circumstances exist, which indicate their essential difference. These are, principally, -the less specific gravity of Arontianite compared with that of witherite; the difference of the habitudes of the carbonic acid combined with both of them; the various form of the crystals produced by the combination of these earths with the nitric, acetic, and, above all, with the muriatic acid; the power of strontian-earth to crystallize in simple water; and principally, also, the red colour, which the earth of strontian imparts to slame in various ways of preparation.

Since, therefore, the *ftrontian-earth* is peculiarly diffinguished by the above enumerated properties, as well as in other respects, there is nothing that can prevent it from being acknowledged and established as a new, distinct, and simple earth.

#### XIX.

### CHEMICAL EXAMINATION

OF

#### LEPIDOLITE.\*

THE fossil brought into notice, by the name Lilalite, was first taken for a species of gypsum, and then for a species of Zeolite. The first account published of it is that of Born, in the Chemische Annalen, 1791, B. 2. S. 196, where he writes of it as follows.

"At Rozena, in Moravia, there are found, between blocks of granite, uncommonly large and heavy maffes of a dense violet zeolite, whose texture, like that of the aventurino, exhibits white shining lamellas, that, at the first view, might be looked upon as micaceous particles. But these, on more accurate investigation, are found to be nothing else but white lamellas of zeolite, having the lustre of the mother of pearl. When ignited between coals, it sufes to a porous slag. In a strong fire it runs into a dense, white glass, resembling wax. At an increased heat its colour disappears, which last seems to originate from manganese. Some pieces of this sossil are firmly implanted on quarz; others are traversed by granite; but, for the most part, it is perfectly pure, and its chief constituent part is silex.

<sup>\*</sup> Beobachtungen und Entdeckungen aus der Naturkunde, vol. v. t St. S. 59.

To this description, given by Born, I may add, that the hardness of this stone is but inconsiderable, as it may be scraped with the nail of the singer. Notwitstanding this, it is capable of some polish when cut into plates.

Its specific gravity is but middling, viz. 2,816 \*

The opinion of those, who thought it to be a species of gypsum, (sulphat of lime) I found totally unsupported. But how justly this fossil may be ranked with the zeolites, will be understood from the result of the present analysis, the subject of which was its amethyst-red variety.

#### A.

- a) When this fossil is heated to redness upon charcoal, before the blow-pipe, it first frothes up moderately, but soon after it runs into a perfectly sused milk-white pearl, which, in most of its parts, is transparent; but, if broken by the hammer, yields fragments entirely clear.
  - b) By a neutral phosphat it is gradually dissolved, and then it sufes into a semi-translucid white pearl.
- c) Vitrified boracic acid (glass of borax) dissolves it more readily, and suses with it into clear colourless spherules.
- d) On melting it with foda, in the filver spoon, it moderately boils, and a mass, speckled red and blue, is produced.

<sup>\*</sup> The external characters of Lepidolite are described by Karsten, loc. cit. pag. 71.

e) Exposed

e) Exposed to red-heat, in a small crucible, for half an hour, it loses its amethystine colour, and that of a light isabella succeeds \*.

#### B.

- a) Four hundred grains of the levigated fosfil, mixed with the same quantity of carbonated pot-ash, were exposed to a moderate red-heat, in a porcelain crucible, for two hours. They did not suse, but concreted into a considerably firm mass, which, being removed from the vessel before cooling, had a dark verdigris colour, and in some parts an amethyst red. Water which was poured upon it, after grinding, became tinged of a deep grass-green. A few drops of nitric acid changed this green colour to a rose-red. But as soon as sulphureous acid has been added, it immediately destroyed this last colour, and the sluid, under examination, was rendered colourless. This change of colour, therefore, indicated, that the red colour of the sofiil is owing to a portion of manganese.
- b) I faturated that alkaline fluid with muriatic acid, added to excefs, and the folution of the foluble parts was affifted by digeftion. This muriatic folution, exhibiting a bright yellow colour, was feparated from the *filiceous earth* by filtration; which last proved very much inflated, and, when washed, desiccated, and ignited, weighed 212 grains.
- c) After the muriatic folution had been concentrated, by distillation from a retort, it still deposited some filiceous earth, amounting to four grains after ignition. By its subsequent

<sup>\*</sup> Concerning the habitudes of Lepidolite, in the fire of the porcelain-furnace, fee N. 54 of the 1st Essay.

combination with Prussian alkali, a dirty blueish precipitate, of a woolly slocculent form, was thrown down, which, upon ignition, gave a residue of four grains, consisting of intermingled light-brown and grey-white particles. This residue was little, if at all, attracted by the magnet. When suffed with phosphated alkali, it formed a milk-white and semi-translucid pearl. Glass of borax gave it first a green, and then a garnet red colour. Soda produced with it a black scoria, in which, with the help of the microscope, extremely minute, silver-white metallic globules could be seen.

The portion of iron that was contained in the quantity of pruffiated pot-ash, requisite to effect that precipitation, makes one grain; which being subtracted, there remain three grains for the iron and the manganese, constituting the metallic contents of the stone.

- d) I now mixed the folution with caustic (pure) ammoniac. A copious precipitate, in the form of flour-paste, fell down, which I directly separated by filtering. When edulcorated, dried, and exposed to gentle red-heat, it was found to be aluminous earth, of 152 grains in weight.
- e) The fluid remaining, after the separation of the argil, was combined with carbonated alkalis; but no new precipitate ensued. Therefore, I evaporated the liquor to dryness, dissolved again the saline mass in water, and collected the slight portion of earth which then separated. It weighed three grains, consisting of two grains of silex and one grain of alumine.

In the above decomposed 400 grains of the fossil, therefore, existed:

Ignited

# 242 XIX Examination of Lepidolite.

Ignited filex B. b) 212	a shipsole
c) 4	
Alumine d) 152	} . 153
(e)	5
Manganese and	grander bio
oxyded iron . c)	3
the state of the s	
	374
Which gives for one hundred parts,	A STATE OF THE STATE OF
Silex 54,50	
Alumine	5
Manganese and oxyd of iron . 0,7	Surger Mark Stranger
resolution de la folkon de la prise de la com-	my line of the
93,5	0
Loss in aqueous particles 6,5	0
Separation of the second of the second	O MAN MAN
C.	Marie of the

As the fufibility of lepidolite, without addition of any extraneous fubflance, induced me to fufpect, that, among its conflituent parts, fome calcareous earth might be found, I refolved to repeat its analysis.

For this reason, I again subjected 400 grains of it to the same analytical process. Having separated the siliceous earth, the quantity of which was the same in proportion with that of the first process, I treated the solution, then obtained, with mild vegetable alkali, and at a raised temperature. The precipitate produced in the process, and washed, was divided into sour equal parts while yet moist.

a) Upon one fourth part I affused dilute sulphuric acid, which soon dissolved it into a weak reddish liquor. After a short

thort repole, a reddish-grey sediment fell down, which, carefully collected and dried, weighed half a grain, and readily suffed upon charcoal to a black-grey scoria. When a small portion of this last had been thrown into melted phosphoric salt, it gradually dissolved, and gave a green tinge to the saline bead. But when the whole of it was put in, the small globule lost its transparency and assumed a blue colour. At the same time a very minute grey-white metallic grain became discernible, which, when separated from the spherule, would not obey the magnet. As that metallic bead hardly weighed  $\frac{1}{3}$  of a grain, it would not admit of farther investigation. Perhaps it was phospat of iron. The saline bead, by imbibing moisture, was again divested of its blue colour, and turned brown-red.

The fulphuric folution, left in a colourless state, after the separation of the above deposition, was committed to spontaneous exhalation; and it then shot, by degrees, into perfect crystals of alum. At last there remained a thickish residue, which, previously diluted with water, and warmed, I combined with vegetable alkali. A slight quantity of a loose, whitish precipitate fell down of \(\frac{1}{3}\) grain in weight, when edulcorated and dried. By exposure to air, it acquired a brown colour, and by ignition upon charcoal it became black. Treated with a neutral phosphat, with the affishance of the blow-pipe, it soon melted to a small globule, which, by turns, appeared colourless, when acted on by the inner stame, and amethyst-red, by the outer-stame. Thus it proved to be manganese.

b) Upon another fourth-part of the precipitate, vinegar, distilled and concentrated by freezing, was affused, and decanted again from it, after 12 hours. In order to try this acetous liquor for calcareous earth, it was divided into three parts, each of which was separately treated; one, with

exalic

oxalic acid; another, with oxalat of pot-ash; the third with sulphuric acid. But in no case any indication of lime was obfervable; all these three trials remaining perfectly clear. The acetous solution merely contained some of argil, which I precipitated from it by pot-ash.

- c) The third portion of the precipitate, likewise before drying, was introduced into heated caustic alkaline lye: it liquefied in it, leaving a small brownish residue, confishing of the above mentioned metallic ingredient of the stone, together with a slight trace of silex.
- d) Lastly, the remaining fourth-part of the yet moist precipitate I suffered completely to desiccate in a warm place. The earth was of a milk-white, and weighed 54 grains. It lost nothing of its colour, and but little of its bulk, by a strong ignition for two hours in a small and covered crucible. But its weight was the more diminished, as it then weighed  $37\frac{1}{2}$  grains only.

Therefore, the result of the first analysis was confirmed, as to the main point, by this second decomposition of lepidolite.

But the total absence of calcareous earth, in the mixture of this fossil, is highly worth remarking. For silex and argil, when in their purest state, are absolutely insusible in any proportion of the mixture; but become susible, when lime in a proportionate quantity enters into the combination. On the contrary, the lepidolite, consisting merely of silex and argil, and without any portion of lime, is of so easy susion, that it properly may be reckoned among the most susible stones.

In many cases, the metallic oxyds, indeed, likewise act as powerful fluxing media; yet, in the present instance, the metallic

metallic portion is too fmall to be capable of being confidered, with any degree of probability, as the cause of the fusibility of this fossil.

Is there, perhaps, in those argillaceous stones that sufe in the fire, without any admixture either of absorbent earths or of metallic calces being found in them, some hidden principle, promoting their suffice, which is hitherto unknown, and is of a volatile nature? Fel-spar affords an instance of them. This stone, while continuing in its natural unaltered state, runs into a glass; whereas porcelain-clay, which results from its decay, is insuffible in the highest degree. Therefore, it might not seem unreasonable to suppose, that during this transition of vitristable sel-spar into insusible clay, some volatile substance, as yet unknown, and capable of promoting sussion, might escape; did we not, on the contrary, find, by experience, that vitristed sel-spar, if again exposed to fire, enters again into sussion, in the same manner as it did the first time.

It remains yet to investigate, whether the lepidolite is justly ranked, as Born would have it, among the zeolites. When we attempt, in the mineralogical fystem, to separate and to determine the various species of fossis, not in a vague manner, but according to fixed characters; the question is, then, in which of its properties does the specifical character of zeolite consist? I think, in the following: that it is moderately hard, and gives no sparks with steel; that, urged by the slame upon charcoal, it is rendered milk-white and opake, swelling much at the same time, and forming ramose excrescences, yet without actually susing into a globule; and that, besides the filiceous and aluminous earths, the calcareous, likewise, is an effential constituent part of it. The mother-of-pearl-like lustre, the gelatinous coagulum, which it forms with acids, and its phosphorescent

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nature on ignition, cannot be confidered as any of its effential properties.

Since, therefore, the present fossil does not shew the same appearances upon charcoal as the zeolite, but as it intumesces but moderately, while, at the same time, it suffers into a perfect, and, in part, translucid, round globule; and, moreover, as it is absolutely destitute of lime for one of its constituent parts, these sacts afford sufficient ground to distinguish it from zeolite, in the systematical arrangement of sossils, and to rank it as a distinct species.

As I entertained some doubts whether the name Lilalite, given to that fossil at its first introduction into public notice, would bear sound criticism, I recommended, in its stead, the denomination of Lepidolite (scale-stone), for its specific name; because this sossil shines on its sracture like an aggregate of minute fish-scales\*.

A particular fossil has lately been discovered in the vicinity of the lepidolite, which consists of long columnar

<sup>\*</sup> A more accurate account of the native place of Lepidolite, together with a full description of its external characters, may be seen in Fichtel's Mineralogische Aussauze, Vienna, 1794, page 226. There the author also endeavours to defend the name Lilalite, given to this stone by its first discoverer, the Abbé Poda, of Neuhaus, against mine, Lepidolite. But, in my opinion, that appellation is erroneous; is, because it is against the common rule to derive the names of species from colours, since these are changeable, and since even this very sossil has already been met with, in various shades, of violet blue, amethyst red, and white, besides the lilac colour, of which the discoverer first sound it. 2dly, Because the word Lilalite, being compounded of the Arabic (Lilac, Lilach), and the Greek (Lithos, stone), is a nomen hybridum.

eryftals, longitudinally striated, and transversing grey-white quarz, and occurs, with various degradrations, of a palered colour, in some specimens passing into the isabella, and into green. This mineral was pretended, by some, to be crystallized lilalite: but, even without having yet performed a perfect analysis of it, I am already convinced, that it by no means belongs so that soffil, but to the sortaceous beryl, (shorlite,—by Kirwan); with which it agrees not only in its extarnal appearance, but also in its habiatudes, in the dry way.

XX.

### CHEMICAL EXAMINATION

OF

#### CIMOLITE.

HE Cimolic earth (Cimolia Plinii), or the Cimolite, as I shall call it for the fake of brevity, belongs to those bodies of the mineral kingdom, of which an historical knowledge has, indeed, reached our age, from the writings of ancient classics, such as Theophrastus, especially, Dioscorides and Pliny; but a familiar acquaintance with them has gradually been loft fince the time of those authors. We learn from the works of those old naturalists, that the Greeks, as well as the Romans, besides its medical use, employed the cimolic earth for technical purposes, in the preparation and cleaning of their stuffs and wearing apparel. This is fhewn, among others, in the following passage of Pliny\*:-Cretæ plura genera. Ex iis Cimoliæ duo ad medicos pertinentia: candidum et ad purpurissum inclinans. And having first mentioned its various applications in medicine, he thus continues: Est et alius usus in vestibus. Nam sarda. quæ adfertur e Sardinia, candidis tantum adfumitur, inutilis versicoloribus: et est vilissima omnium Cimoliæ generum. Pretiofior Umbrica, et quam vocant Saxum.-Primum abluitur vestis Sarda, dein sulphure suffitur: mox desquamatur Cimolia, quæ est coloris veri. Fucatus enim deprehenditur, nigrescitque, et funditur sulphure. Veros autem et pretiosos

<sup>\*</sup> Hist. Natural, lib. xxxv. chap. lvii.

colores emollit Cimolia, et quodam nitore exhilarat contriftatos fulphure.

What later writers have mentioned concerning cimolite (Agricola\*, for instance), are mere compilations taken out of those ancient authors. Tournefort, however, is to be excepted, who certainly saw it in his travels through the Levant, but has erroneously taken it for an earth of the calcareous kind, distinguished from common calcareous earth, as he thought, by its soapy fatness.

It is by the kind communication of John Hawkins, Efq. who, in his voyage to the Grecian islands, made for the advancement of Natural History, has collected the genuine cimolic earth on the island Cimolo itself, or Argentiera, as it is called at present, that I have been enabled to revive the knowledge of this sofiil, hitherto lost both to Natural History and Technology, and, at the same time, to undertake its chemical analysis.

The colour of cimolite is a light greyish-white, inclining to pearl-grey. But this colour is somewhat changed by exposure to air, where it acquires a reddish tint. It is, therefore, probable, that the cimolia ad purpurissum inclinans, of Pliny, as well as his candida, are both one and the same species; since the first, or the externally reddish one, is, on the fracture, as white as the second.

Cimolite is found massive, and probably it occurs in vast ftrata. Its fracture is earthy, uneven, and its texture more or less slaty. It is thoroughly opake, and does not stain

<sup>\*</sup> De Natura Fossilium, lib. ii.

considerably. When scraped with a knife, it yields shavings, like steatites, and the abraided surface is smooth, and of a greasy lustre. It adheres pretty firmly to the tongue.

Yet this stone, though it is so soft as to be scraped by the nail, is but with difficulty broken, and, in consequence of this tenacity, not easily pulverized.

Its specific gravity I found exactly double that of water; that is, 2,000.

Small milk-white crystalline grains of quarz are found here and there fingly diffeminated in its substance.

The flaty texture, which, in the dry pieces of cimolite, is often but confusedly, perceived, appears most distinctly when they are steeped in water. Cimolite is immediately penetrated by water, and it then developes itself into thin laminæ, of a curved-slaty form.

Cimolite, if triturated with water, diffolves into a foft, pap-like mass, though not slippery in the strict sense. An bundred grains of it, ground with three ounces of water, assumed the appearance and consistence of a thickish cream. When this mass is left to desiccate in the grinding-dish, it detaches itself from its sides, in hard-dried, ribbon-like, and somewhat slexible bands. In this state, cimolite is pulverized with still greater difficulty than before.

In order to obtain fome knowledge of the efficacy and utility of cimolite, in a technical view, I partially greafed finall pieces of filk and woollen cloth with oil of almonds, and covered those oily spots, on both sides, with cimolite, work-

worked by grinding with water to the thickness of a liniment. They were then exposed to dry in the air. The next day I dipped those stuffs in water, and saw, with surprize, that, by a slight washing, the cimolite, together with all the greafy spots to which it had been applied, were removed, without leaving the slightest trace. After drying, the stuffs were again found possessed of their former cleanliness, and the original beauty of their colours completely restored.

Trivial and imperfect as this experiment was, it ferved, however, fully to confirm the technical use of cimolite, extolled by the ancient writers: and hence, too, it appears much to surpass the best English fuller's earth. To revive the importation of cimolite, as an article of merchandise, would therefore be very desirable for the manufactures subfervient to our clothing, as well as for common use; especially for precious stuffs of delicate colours, that will not well bear the agency of acids and alkaline soaps. Whence, also, the inhabitants of Argentiera make as much use of it, in the washing and bleaching of their stuffs, at this very day, as in remote ages.

To acquire a chemical knowledge of cimolite, I made the following experiments.

#### A.

a) Hundred grains of cimolite, in entire pieces, were exposed, for half an hour, to the fire of the wind-furnace, in a covered crucible. After cooling, it was found grossly split into slaty fragments, of uneven surfaces. This was accompanied, at the commencement of ignition, with a surprisingly strong noise. The cimolite acquired, at first, a brown-

brownish-grey colour, which, however, again disappeared. It lost 12 grains in weight.

b) Ignited, alone, upon charcoal, before the blow-pipe, it first turns dark-grey; but, after complete ignition, it again becomes white.

When cimolite is conveyed into phosphoric falt, already fused, it is gradually dissolved by it, and runs into a colour-less pearl.

Glass of borax, likewise, dissolves cimolite; but is tinged by it of a light-brown.

Soda fuses with it into a milk-white globule \*.

B.

Hundred grains of cimolite were triturated with water, and treated with 300 grains of strong sulphuric acid, by which management the white colour of the blended mass was changed to a pale slesh-red. For the purpose of separating the siliceous earth, I evaporated the mixture in a warm temperature, covered it again with water, and subjected it to digestion. However, it continued turbid and muddy; so that I could not fully succeed in separating the silex. I, therefore, employed that mixture to convince mysfels of the absence, or presence, of magnesia, among the constituent parts of that sofsil. With this view, I saturated it, with the assistance of heat, with mild calcareous earth,

<sup>\*</sup> The habitudes of cimolite, in the fire of the porcelain-furnace, have been mentioned at No. 27 of the first essay.

and reduced the fluid, when filtered, to a smaller bulk, by evaporation; carefully removing, at the same time, the selenite, as it appeared. Yet no trace of sulphat of magnesia was perceptible.

#### C.

- a) Two hundred grains of cimolite, mixed, and ignited with thrice their quantity of caustic pot-ash, afforded, after cooling, a blueish, and greenish-white mass. From this, when softened with water, the undissolved part was separated by filtering.
- b) The alkaline liquor had no colour. It at first continued clear, on being faturated with sulphuric acid; but, at a raised temperature, it coagulated to the confishence of jelly. Upon the affusion of more water, and proper digestion, siliceous earth separated, weighing 44 grains, when ignited.
- c) The earth, which was not taken up by the alkali (a), was of a grey white, and weighed 220 grains. It dissolved, by degrees, in sulphuric acid, which was added to it, and left behind some siliceous earth, which weighed five grains, after ignition.
- d) Both the sulphuric solutions (b) and (c) were next added together, and partly evaporated; after which, crystals of alum appeared, as the liquor cooled. The remainder of the sluid congealed, on farther evaporation, to a jelly. When mixed with water, digested, and filtered, there remained siliceous earth, in the form of pellucid vitreous grains, the weight of which, after grinding and ignition, was 64 grains.

f) When the portion of iron had been separated, I added a small quantity of vegetable alkali to that part of the solution which yet remained. By this treatment, and subsequent evaporations, I obtained aluminous crystals, in succession, to the end. But, at the same time, there still separated some siliceous earth, amounting to 13 grains, when heated to redness.

g) The whole of the alum (fulphat of alumine) obtained, was re-diffolved in water, and the argillaceous earth feparated by vegetable alkali. This argil, depurated and gnited, gave 46 gr ains in weight.

Therefore, the above 200 grains of cimit e produced:

Ignited Silex . C. b)	44)	
c) d)	5 64	126 grains.
f)	13)	
Alumine . g)		. 46
Ignited oxyd of iron c)		. 27
Loss by ignition A. a)		 24
		1
All the transfer of the second of the second		1081 grains.

Whence, one hundred parts of cimolite contain:

## XX. Examination of Cimolite.

 Silex
 63

 Alumine
 23

 Oxyd of iron
 1,25

 Water
 12

99,25

255

With regard to these constituent parts, and their proportions to each other, the cimolite might properly be placed in the mineralogical system along with the common species of clay: but its distinguishing character, on which, also, its other physical properties depend, undoubtedly consists in the minutely divided state of the siliceous ingredient, as well as the most intimate mixture of this last with the argillaceous part.

#### XXI.

#### CHEMICAL EXAMINATION

OF THE

# MAGNESIAN-SPAR (Bitterspath.)

(Crystallized Muricalcite, Compound Spar, of Kirwan.)

#### A \*.

AMONG the Tyrolese fossils, and those of Salzburg, so remarkable by their variety, there occur certain rhombic crystals, which are most frequently sound singly interspersed in a slaty chlorite (Schneidestein), mixed with silvergrey magnesian lamellas. Those crystals have been called rhomboidal spar on account of their sigure, or magnesian-spar (Bitter-spath) on account of this supposed constituent part.

The colour of those crystals is greyish-white, passing more or less into yellow or reddish. They commonly form regular rhombs, from one half to three fourths of an inch thick; but they are also found of a greater size. Their external splendour is only moderate; but internally they possess a high lustre. Their fracture is of the straight soliated kind; but the sigure of their fragments is rhomboidal. They are mostly transparent in a great degree; but the fragments of the larger crystals are nearly pellucid; and if held against the light, they exhibit changing

<sup>\*</sup> Beobachtungen und Entdeckungen aus der Naturkunde, vol. v. page 51.

rainbow-colours. Their hardness is a medium between that of calcareous-spar and that of sel-spar; as the first may be scratched by them, but they themselves may be scratched by the second\*.

Their specific gravity I have found to be 2,480.

- a) An entire piece, weighing 100 grains, was ignited in a covered crucible for two hours; yet, notwishstanding its sparry texture, it remained entire, without slying in pieces. It was rendered ash-grey, and wholly opake, though preferving some lustre. At the same time its weight was lessened 45 grains †.
- b) The action of mineral acids upon magnefian-spar, while in gross fragments, is not perceptible; but if pulverized, they attack and dissolve it gradually, attended with a continued gentle effervescence. With the sulphuric acid, selenite is generated, and the supernatant solution is of a pale-reddish colour. Nitric acid produces a colourless solution, and the muriatic acid a yellow one.

But when pieces of calcined magnefian-spar are employed, the folution goes on rapidly. And in that case the nitric acid leaves a metallic residue behind, which separates of a brown-red colour.

<sup>\*</sup> More circumstantial descriptions of the external characters of this fossil have been given by Karsten in Beob. u. Entd. a. d. Naturk. vol. v. page 56.—Born Catal. d. l. Collect. d. Fossils, vol. i. page 386, with the name, Chaux magnesiée;—and Fichtel. Minerl. Aufsätze, page 189.

<sup>†</sup> For the habitudes of magnefian spar in a porcelain-heat, see N. 16 of the first Essay.

- c) Three bundred grains of finely powdered magnefianfpar, mixed with an equal quantity of pot-ash, were ignited for two hours in a crucible. The mass returned black out of the fire, except that its middle part was rendered of a dark ash-grey. When triturated, and covered with water, it became light-green. Muriatic acid assured upon it, in sufficient quantity, dissolved the whole, forming a clear golden-yellow tincture.
- d) This folution was decomposed by means of carbonated pot-ash, and with the affistance of heat. Sulphuric acid was poured upon the precipitate, previously diluted with water, in such a quantity that the acid was predominant. Abundance of selenite (sulphat of lime) was thus produced; which separated from the remaining sluid.
- e) I next evaporated the folution, that remained after the feparation of the felenite, and which contained fulphat of magnefia, and a fmall portion of fulphated oxyd of iron; carrying on the operation, until the faline mass appeared in a dry state. This last I subjected to a red-heat for two hours, re-dissolving it afterwards in hot water. Upon the filter there remained a subtle red-brown oxyd of iron, weighing nine grains, and wholly obeying the magnet.
- f) The folution, now freed from the iron, afforded, by crystallization, a pure sulphat of magnesia; which, when properly decomposed by pot-ash, and with the assistance of heat, yielded 133 grains of carbonated magnesia.
- g) The fulphat of lime (d), decomposed by dissolved carbonat of pot-ash, furnished 160 grains of crude calcareous earth. To examine whether this last still contained any magnesia, I dissolved it again in nitric acid, mixed the solution with caustic ammoniac, and siltered the precipitate then

then formed. This immediately diffolved in sulphuric acid, which was added, and being precipitated by carbonated potaff, it still yielded three grains of magnesian earth; which subtracted, leaves, therefore, 157 grains for the quantity of crude calcareous earth, or carbonat of lime:

Consequently, I obtained from the above 300 grains of the Tyrolese magnesian-spar:

Carbonat of lime					157 9	grs
Magnesia	f	133 }			136	
Oxyd of iron, containing	8)	3 3	-	-		
fome manganese .	e).		?	7	,9	
					302 9	

As no loss of weight, but rather an excess, appears in the sum of the constituent parts, given separately, we may conclude, that those ingredients might, perhaps, have been capable of undergoing a still greater degree of desiccation.

Therefore a hundred parts of magnesian-spar consist of:

Carbonat	of li	me				0.			•			52
Magnefic	7 .	¥							à			45
Oxyd of	iron,	im	pre	gna	ted	with	6 1	mang	ran	ese		3
										,	-	-
												100

B.

Although it is only a few years fince this fossil was brought to Vienna by some Tyrolese dealers in minerals of their country, and from thence brought into farther notice; yet it seems that Woulse has already been acquainted

with

with it at an earlier period. For the fossil, which he examined, and described in the *Philosoph*. Trans. for 1779\* by the name of compound spar, agrees with the Tyrolese.

It is also proved, that the magnesian-spar is found not only on the borders of the Tyrolese and Salzburg mountains, but likewise in other places, by the following examination of a spar of that kind, coming from Taberg, in Wermeland, a province of Sweden.

It occurs in the fossil, in which I have found it of a grey-white colour, with a strong lustre, nearly resembling that of the mother of pearl, in semi-pellucid and rhomboidal fragments. With regard to its fracture, it can hardly be distinguished from that variety of the Tyrolese magnesian-spar, which surnished the subject of the foregoing analysis. The only difference consists in its external form; that is, it does not occur in single interspersed crystals, like the last, but in masses; and it is accompanied by a green, compact, indurated clay, and a gross-soliated, deep verdigris-green talc (magnesian earth.)

- a) A finall piece of it, ignited per se upon charcoal, turns brown without splitting. It dissolves, by sussion, in a neutral phosphat, and forms a clear, colourless bead. Nearly the same effect is produced by glass of borax. When heated to redness with soda on the melting-spoon, it suses into a dull, blueish-green globule.
- b) Two hundred grains, reduced to powder, diffolved gradually, and with effervescence, in the muriatic acid. Caustic ammoniac, added to the yellow solution, produced a light slocculent precipitate of a dirty green, which on the sil-

<sup>\*\*</sup> Kirwan's Elements of Mineralogy, Lond. 1794. vol. i. p. 92.

tering paper changed to a brown, and, heated to redness, yielded 4½ grains of oxyd of iron.

- c) The folution, now rendered colourless, was evaporated to a smaller compass, mixed with one third part of alkohol, and combined with as much sulphuric acid as was necessary to precipitate the siliceous earth from the selenite or gypsum (sulphat of lime), which was then separated, and washed with a mixture of alkohol and water.
- d) When the whole of the liquor had been again reduced by evaporation, I precipitated its magnefian earth, by means of carbonated pot-ash, affisted by a boiling heat. It did not prove to be as loose as it ought to have been, and thus it shewed, that it was not yet pure. Hence, on the assume as deposited, which I added to the first. The solution, thus freed from it, then afforded pure sulphat of magnesia (Epsom-salt), which, re-dissolved and decomposed in a boiling heat, by alkaline carbonat, afforded 50 grains of carbonated magnesia.
- e) The felenite also was decomposed, by boiling with water and carbonated pot-ash. Thus I procured from it 146 grains of mild, or carbonated calcareous earth.

This Swedish magnesian-spar, therefore, contains much less magnesia than the Tyrolese; and the proportion of its constituent parts in one hundred is the following:

Carbonat of lime		73
Magnefia		25
Oxyd of iron, containing a little manganese		2,25
	-23	
		100,25
		VVII

#### XXII.

### EXAMINATION

OF THE SUPPOSED

#### MURIACITE.

THE review of our present knowledge of mineral bodies would undoubtedly be much more extensive, and at the same time require much sewer corrections, if every newly discovered fossil were immediately put to the chemical test, and not received into the systematical arrangement, till it had been stamped with the authentic seal of truth.

The muriacite does not feem to be as yet fo generally known, that I may not hope to be able to prevent its farther introduction to the public in an erroneous shape, by means of the examination which I am going to describe.

Fichtel\* gives the following account of it.

Abbé Poda has lately discovered a new species of calcareous earth, which, by reason of its constituent parts, he calls muriated lime, or muriacite, according to the new method of nominating sossils; because that mineral is composed of calcareous earth, muriatic acid, and water. The miners in the saltpits at Hall, in Tyrol, call it scaly gypsum (schuppiger gyps-stein.) But, besides this difference in its constituent parts, it is also farther distinguished from the compast gypsum: 1st, by its greater bardness; 2dly, by the quadrilateral,

<sup>\*</sup> See his Mineralogische Aufsaetze. Vienna, 1794, page 228.

rectangular

restangular scales or laminas, of which it is entirely composed; and 3dly, by its much more difficult solution in water, of which, at a mean temperature, it requires 4300 parts. We expect to receive from the Abbé himself the circumstantial description of this new species of calcareous earth.

This fossil the more deserved a chemical examination, as hereby we might be enabled to understand by what means Nature could produce a combination of the earthy saline kind, which in the dry as well as in the crystallized state is so much disposed to deliquescence; but which, as here is supposed, exists in a dry and compact state, and at the same time requires such an excessive quantity of water to be disposed.

That specimen, which has been sent me from Vienna, as genuine muriacite of Hall, in Tyrol, is an aggregate of rectangular, four-sided plates, of a light-grey, black-grey, and in part reddish colour, with bright specular surfaces; and hence not ill resembing gross-soliated hornblende. By the taste, and partly even by bare inspection, it betrays an admixture of some portion of rock-salt. Trituration reduces it to a white-grey powder.

- a) Upon five hundred grains of it alkohol was poured; which, after 24 hours, I again separated by filtering. The ardent spirit continued colourless; and when evaporated, it lest pure common salt, or muriat of soda, behind, in the state of dry crystals.
- b) This being done, water was affused upon the powder, until all the saline parts were lixiviated. This aqueous solution, which was likewise colourless, being evaporated to dryness, left also common salt behind; but contaminated with gypsum.

5 4

# 264 XXII. Examination of Muriacite.

- c) The falt obtained in both extractions, and added together, weighed 91 grains. By the affusion of one part of alkohol, mixed with three of water, all the falt was disfolved, and the residual gypsum amounted to 17 grains. This determines the quantity of the muriat of soda at 74 grains.
- d) I next treated the powder (which had been previously extracted both by alkohol and water) with dilute nitric acid; digesting it gently. Carbonated pot-ash, added to the nitrated shuid which was again separated, threw down an earth, weighing 26 grains when dried, and consisting of calcareous earth, impregnated with iron.
- e) The refidue was boiled with water and carbonated potash. The sluid, filtered off, was then saturated with nitric acid. By the addition of muriated barytes, a precipitate was obtained, consisting of sulphat of barytes.
- f) Upon the edulcorated residue I poured again some nitric acid, which produced a great effervescence. After due digestion I separated the fluid by filtration; and, while yet boiling, I combined it with alkali, by which treatment I obtained 76 grains of carbonated lime. But as this last had existed in the sossil, in a state of combination with the sulphuric acid, mentioned at (e), we must only reckon 120 grains of gypsum, or sulphat of lime.
- g) What remained, after the extraction with nitric acid, weighed now 265 grains. It was a minute, light-grey, micaceous fand.

In these 500 grains of the fossil, therefore, have been found:

Muriat

XXII. Examination of Muriacite.	265
Muriat of Soda c)	74
Gypsum c) 17 f) 120 }	137
Carbonat of lime	
Sandy refidue g)	265
WATEL EN LUIE	502 grs:

Hence, the existence of a native muriat of lime in the concrete state, and also the name of muriacite, which has been given to it, are incompatible with this result.

XXIII.

# EXAMINATION

OF THE

### NATIVE ALUM

odl as and a Miseno. From Mifeno.

THE alum cavern (grotta di alume) at the Cape Miseno, near Naples, which, as it were, serves as a laboratory, where Nature alone, unassisted by art, is constantly producing perfect alum, has been mentioned only by sew of the Naturalists who have visited that country. Professor Spallanzani\* says of this remarkable grotto:—Before the traveller reaches the promontory Miseno, he meets with its harbour, which, there is no doubt, is likewise a crater; as it is surrounded on all sides with eminences. Those elevations consist of tusas, and on one side of them, a little above the sea, there is seen an aperture, made by art, which is called grotta di Miseno; and where sulphat of alumine (alum) continually efforesces. This salt is not known by the natives, or at least they pay no attention to it.

The subject of the following analysis has been a portion of the alum of Miseno, collected on the spot itself, and given to me by that worthy naturalist, John Hawkins, Esq.

All faline efflorescences agree in this, that while they continue in the dry state, they give no sign of the crystal-line sigure, that is peculiar to each particular species of salt. They always appear of a sibrous form. For this

reason also, this effloresced native alum does not present its appropriate octahedral form, but is found in small, detached, and roundish accumulations, of very thin and short fibres, possessed of a white colour, and silky lustre, though in part intermingled with minute crystalline grains.

- a) One thousand grains of this native alum, dissolved in 10 ounces of boiling water, left 120 grains of a yellowish grey earth on the filtering paper.
- b) The clear folution, when evaporated for the purpose of crystallization, gradually, and alone, afforded 470 grains of pure, clear alum, in octahedral crystals; although their formation had not been promoted by the addition of potassh. At the same time 25 grains of felenite (gypsum) appeared.
- c) Those 470 grains of crystallized alum, re-dissolved in water, were decomposed, while yet boiling, by carbonated lime. After the separation of the gypsum then generated, I evaporated the remaining stud, along with the washings, to a smaller bulk, and freed it from the selenite, which still continued to appear. It yielded 27 grains of sulphat of pot-ash.
- d) After this, the remainder of the folution of the crude alum, that would no longer shoot into solid crystals, was inspissated, by farther evaporation, to a grey-white, uncluous mass; being but an imperfect sulphat of alumine. This substance might, in the present case, be considered as a true mineral butter (Bergbutter). By affusion of water it formed a somewhat turbid solution; and, by being then treated with a small portion of pot-ash, it yet afforded 290 grains of concrete crystals of alum.

- e) The above 120 grains of earthy refidue (a) were boiled with mild vegetable alkali and water. The filtered liquor was then faturated to excefs with muriatic acid, and combined with muriated barytes. Upon which fulphat of barytes fell down.
- f) I now drenched in muriatic acid the refidue, that had been boiled with alkali. This last, again separated from it by the filter, was next saturated with carbonated pot-ash. Eleven grains of a yellowish earth were then precipitated; which, upon closer examination, were found to consist of two grains of oxyd of iron, and nine grains of carbonated lime; which last, together with that which had been indicated in combination with sulphuric acid by the muriated barytes (e), amounted to 15 grains of selenite.
- g) The final remainder, which had refifted the attack of the muriatic acid, weighed 92 grains, and was a fandy earth, of a greenish-grey colour, meager, and harsh to the feel.

From 1000 lbs. therefore, of this rough, native alum from Miseno, may be produced, barely by folution in water, and subsequent crystallization:

I)	Alu	ım, provi	ded by N	Tature her,	self with	
	the	requisite	quantity	of pot-ash		. 470
			_	771		

2) Alum, whose crystallization is promoted by adding pot-ash . . . . . . 290

760 lbs.

When, therefore, Spallanzani censured the natives for not knowing, or for disregarding this natural product, which is so easily procured, and which, with so little ex-

5

pence, may be made a profitable article of commerce, he was not unsupported by reason. This alum of Miseno, it should seem, might be of the same good quality as that of Tolfa; as it can be rendered as free from iron as this last, and, as besides, the proportion of sulphated pot-ash would not be greater in it than in the Roman alum.

This portion of sulphat of pot-ash, contained in the alum from Miseno, occasions the following question; which indeed it will be still difficult to answer at this time.—It is: As this grotto consists merely of volcanic tusa, in which no vegetation takes place, whence does Nature procure the vegetable alkali, requisite to the generation of the crystallizable alum?

Note. Another instance of the like daily production of native alum occurs at Solfatara, where it is procured, and refined after the manner described by Prof. Breislak. From the following passage of his: Esfais Mineralogiques sur la Solfatare de Pouzzole, Naples, 1792, page 157, it appears-That it is upon the ground of the production of these saline efflorescences, the abundance and richness of which are equally surprizing, and, likewise, of the excessive promptitude of their re-production, that it has been resolved on to establish at Solfatara a manufacture of alum, which of late has been put in activity by Joseph Brentano Cimaroli .-- In the fuller account of it, given page 231. according to which, the aluminous lixivium, by means of boiling, is brought to shoot into crystals in no longer time than 24 hours, there is no mention made of any artificial addition of pot-ash. It is therefore probable, that the alum of Solfatara, like the above of Miseno, is already by Nature provided with that portion of pot-ash, which is necessary to the production of perfectly crystallized alum.

[ 270 ]

XXIV.

EXAMINATION

OF THE

NATIVE SALT-PETRE (Nitre);

From Molfetta.

THE discovery of the native salt-petre-mine, or of the Pulo, producing nitre at Molfetta, in Apulia, made by Abbé Fortis, in the year 1783, could not fail to attract the attention of naturalists, in a degree proportionate to the importance of the subject.

Various philosophers, who have visited and examined the *Pulo* since its discovery, have already given circumstantial descriptions of the natural state of that remarkable pit, as well as an account of the great quantity of nitre which it affords, and of its incomprehensible daily re-production. As to these descriptions, I shall refer the reader chiefly to those published by Prof. *Zimmermann* of *Brunswick\**, and by de Salis Marschlin†.

The nitre employed in the following analytical experiments was collected by John Hawkins, Esq, who has examined that nitre-pit in the March of 1788, in company

<sup>\*</sup> Voyage à la Nitrière Naturelle, qui se trouve à Molfetta, par M. Zimmerman. Paris, 1789.

<sup>†</sup> Reisen in Verschiedene Provinzen des Königreichs Neapel. 1st vol. Zuric and Leipzig.

with Zimmermann and Fortis. In the specimens which I was favoured with, the salt-petre invested fragments of a yellowish-white, compact, lime-stone, forming the stony matter of the Pulo. These fragments, detached from the rock in thin layers, are incrusted with the salt, to the thickness, for the most part, of one sixth of an inch; when it appears in a finely-grained, crystalline form, resembling white refined, or Canary sugar. On some parts of the lime-stone I discovered thin incrustations of a finely-sibrous gypsum, which, in some places, served as a base for the nitre to rest on.

- a) One Thousand grains of this native salt-petre, together with the lime-stone and gypsum to which it adhered, were covered with boiling water. The remaining lumps of stone having been lixiviated, the clear and colourless solution, thus obtained, was next prepared for crystallizing by gentle evaporation. Each shooting of the salt was accompanied by tender, needle-shaped, selenitic crystals. No mother-water remained: but the whole of the solution crystallized, to the last drop, to a perfect prismatic nitre. The selenite, separated from the salt as much as was possible, weighed 40 grains; whereas the salt gave 446 grains.
- b) According to refearches of Professor Vairo\*, this nitre is said to contain common, or sea-salt, in the proportion of I to 6. I therefore expected to obtain, besides the prismatic crystals of the salt-petre, some sea-salt also, in distinct, solitary cubes: but no trace of it, visible to the eye, appeared. For this reason, I attempted to discover its presence by another method. With this view, I re-dissolved, in water, the crystals of nitre which I had obtained, and

<sup>\*</sup> Voyage à la Nitrière Natur. Zimmerman, page 35.

dropped diffolved acetite of barytes into the folution. By these means I obtained a precipitate, consisting of 26 grains of sulphated barytes; which shewed, that  $18\frac{1}{2}$  grains of selenite were still united with the neutral salt. When, after this, I tried the nitrous solution with muriated silver, no more than  $4\frac{1}{2}$  grains of hornsilver (muriat of silver) would precipitate, so that the quantity of common salt, indicated by this last, can be estimated at only two grains. By this, the true quantity of perfectly pure nitre has been reduced to  $425\frac{1}{2}$  grains.

However, I think it more probable, that the neutral muriat, which was mixed with the native nitre, was not muriated foda, but a muriat of pot-ash, or digestive salt, as it is called.

c) Upon the flony substances remaining after the lixiviation of the crude nitre, and which exactly constituted one half of the first weight, viz. 500 grains, I poured muriatic acid. The pieces of lime-stone dissolved with great effervescence; leaving a residue of 196 grains behind, which were white gypsum, of delicate fibres. When the sulphuric acid had been separated from this last, by boiling it in water with carbonated pot-ash, there remanied some carbonat of lime, which dissolved, without any residue, in nitric acid.

The lime-stone, taken up by the muriatic acid, consequently amounted to 304 grains; and, being subjected to farther trial, it proved to be merely calcareous earth, containing a small portion of iron.

Hence, these 1000 grains of nitre from Miseno, here decomposed, have consisted of:

Pure

Pure prism Muriated		b) b)		425½ grains.	-
Selenite		a) b)	40 18½ 196		
Lime-stone		c)		304	
			Lofs	986	
			im' - 11	1000	

By the computation of Prof. Vairo\*, the total mass of falt-petre in the Pulo should amount to between 30 and 40 thousand centners, at 100 lb. each; and the second reproduction of it to more than 50 thousand centners. As, therefore, the alkaline base of prismatic nitre constitutes nearly one half of the whole of that compound, it is obvious, that the question which I have intimated at the close of my last essay, concerning the origin of the vast quantity of vegetable alkali, becomes, in the present case, far more important and interesting to the naturalist. The conjecture, that Nature possesses means of producing that alkali beyond the limits of the vegetable kingdom, nay, even without any immediate influence of vegetation, acquires, by this singular phenomenon, a very high degree of probability.

<sup>\*</sup> Loco Citato. Page 37.

#### XXV.

## CHEMICAL EXAMINATION

OF THE

MINERAL SPRINGS, at Carlsbad.

AMONG the hot mineral springs of Germany, that at Carlsbad, in Bohemia, deserves the particular attention, not only of the physician and the philosopher, but also of every individual that has a due sense of the grand scenes in nature.

The bason of the main-spring, that wonderful reservoir, is, perhaps, the only one of its kind, which Nature herfelf has formed of the conflituent parts of the fpring, and, at the fame time, has covered it by a triple marble-vault, fitted for the collection of the mineral waters produced in the neighbouring fubterraneous laboratory. The boiling mainfpring, rushing, with vehemence, out of the principal apertures of this water-vault, and filling the atmosphere with vaporous clouds; -the inceffant play of the air-bubbles, forcing their way through the smaller rifts and fissures, and rifing in the form of pearls through the river Töpel, which flows immediately upon a confiderable part of that vaulted roof of the spring:-all this, at the first view, invites the mind to reflection; at which the spectator can hardly avoid falling into the pleafing illusion of feeing Nature, that usually likes to operate in a hidden manner, working here close at hand, and, as it were, before his eyes.

I think it needless to enter into a topographical and phyfical description of Carlsbad; because there already exist several accounts and descriptions of it. Among these, the Treatise on Carlsbad, by Dr. Becher, may be considered as the most capital work. I shall, therefore, suppose the reader acquainted with its contents; which, also, in general, I refer to in this essay.

My principal defign is, to state our observations, and the constituent parts of the Carlsbad-water, the decomposition of which we attempted\* at the spot itself, in July 1789; as well as to compare them with those given by Dr. Becker. Besides this, I also intend to say something of the manner which Nature, probably, adopts, in elaborating this mineral spring, by way of a small addition to the theories that have been already offered on this head.

In our refearches, we confined our experiments to the three principal springs: the main-spring, the new spring, and that in the castle. Upon the whole, these, like the other collateral springs that are less made use of, agree with each other in their constituent parts, as well as in the proportion of the more fixed parts, which, in all of them, is much the same. But they differ considerably from each other in their share of carbonic acid; and this variation is regulated by the temperature, which in one spring exceeds that of another; the quantity of carbonic acid being in the inverse ratio of that of the heat. And for this reason, of the abovementioned three springs, main-spring the hottest of all, and whose temperature, upon an average, is of 165° of Farenheit's thermometer, contains the least of the acid.

<sup>\*</sup> For I had the pleasure of making these experiments in company with Count Gessler, Chamberlain and Privy-counsellor to the King of Prussia.

The fpring at the castle, on the contrary, the temperature of which is raised only to 120° or 125° Farenh. contains the greatest portion of carbonic acid\*.

To fave the trouble of a tedious enumeration of the experiments made, I shall give only a short description of our method of proceeding, and mention the results in a summary way.

The constituent parts of the mineral-water of Carlsbad are, in general, carbonat of foda, fulphat of foda, (Glauberfalt), and muriat of foda, or common salt; besides these, carbonated lime, filiceous earth, and a slight trace of oxyd of iron: and, lastly, a proportionate quantity of free, carbonic acid, or, to characterize it more precisely, of carbonic acid gas, solely absorbed by the water; besides free caloric.

On attempting to separate and to catch or obtain the carbonic acid gas, we proceeded in the following manner:—A glass-retort, of 23 cubic inches capacity, was filled with 18 cubic inches of water, taken from the pipe of the springhead; and we lodged it immediately in the sand-pot of a pneumatic distilling apparatus, purposely placed near that spring. The first receiver, into which the neck of the retort was inserted, and the glass-cylinder employed to collect the extricating gas, had been filled with hot-water from the

<sup>\*</sup> When we visited Carlsbad a second time in July 1792, we found the temperature of the

Atmosphere		20
Spring at the castle		37½
New-spring		48 Degrees, Reaumur.
Liebschen-spring		55
Main-spring		551

fpring. Under these circumstances, we expected that the gas would immediately disengage itself, and pass over, at the very first action of the heat on the retort; this, however, happened only a little before the commencement of actual boiling; which last we continued until no more air-bubbles came over.

The air collected in the cylinder amounted to 103 cubic inches. When, therefore, the five cubic inches of atmospheric air, that remained in the retort before the operation, are subtracted, the portion of gas, disengaged from 18 cubic inches of Carlsbad-water, at the main-spring, consists of 5\frac{3}{4} cubic-inches. These were entirely absorbed by limewater, and a calcareous precipitate was produced; fo that nothing remained but the five cubic-inches of atmospheric By this, and by feveral other trials, we were convinced that the gas, difengaged by that mineral water, confifts of pure carbonic acid; that the sulphurated hydrogen gas, which various authors have supposed to exist in it, along with the carbonic acid, is never prefent; and that the presence of sulphureous acid, together with uncombined foda, as fome others have imagined, is not even fo much as possible.

By the fame management, and under the fame circumfrances, an equal quantity of the water of the new-spring afforded nine cubic inches, and of the spring at the castle  $9\frac{1}{2}$ cubic inches, of carbonic acid gas.

I will allow that, by this method of collecting and meafuring the carbonic acid gas, the highest degree of accuracy was not, perhaps, so certainly obtained as it would have been by properly employing the pneumatic quicksilver apparatus, which, at that time, was not in our power at Carlsbad. Nevertheless, I am convinced that this method of conducting and collecting the difengaged gas, through and by means of the hot water of the main-spring, instead of employing mercury for that purpose, cannot have occasioned any considerable difference in the result: for water, in general, when of equal temperature with the natural warmth of the Carlsbad main-spring, is not capable of absorbing a notable portion of carbonic acid. And, besides, such an absorption of that acid gas could the less have taken place in the present instance, as that water, being naturally impregnated with as much carbonic acid as it can contain, was incapable of taking up an additional quantity of that acid.

If this proportion of carbonic acid, found in the abovementioned three fprings at Carlsbad, be compared with that given by Dr. Becher, which, calculated to eighteen cubic inches of water, would amount to feven cubic inches in the main-spring, to  $6\frac{1}{3}$  in the new-spring, and to 10 in that at the castle, there, indeed, occurs a difference; since, in our experiments, the carbonic acid extricated from 18 cubic inches of the main-spring water measured  $1\frac{1}{4}$  cubic inch, and from that at the castle  $\frac{1}{2}$  inch less than Dr. Becher's results, whereas that obtained from the water of the new spring, measured  $2\frac{1}{3}$  cubic inches more.

But as Dr. Becher had the opportunity of employing a quick-filver-apparatus, and as, therefore, I have the less reason to doubt the exactness of his experiments, we are, from thence, the more confirmed in the supposition, that the proportion of the constituent parts of mineral waters is not every year, and, perhaps, not every day and hour exactly the same, but rather variable. This fact is also proved by other phenomena and arguments.

The water of Carlsbad, likewife, contains fome iron, the prefence of which can be afcertained only at the spring itself;

fince the quantity which actually exists in that stuid is so exceedingly small as to escape, in a most rapid and unexpected manner, the senses as well as the efficacy of re-agents. And, for this reason, many persons have absolutely doubted the presence of dissolved iron in these springs. But that they contain it, Dr. Becher has demonstrated by the following experiment. He suspended, by a thread, one half of a nut-gall in a glass bottle of a narrow neck, and filled the vessel on the very spot with water of the main-spring. As soon as the water, in the action of filling, came in contact with the nut-gall, it acquired a reddish colour; but five minutes after, the colour changed to a bright-red, inclining to the violet.

We, likewife, made the fame experiment. Having previously suspended a slice of a gall, by means of a white silk thread, in a glass-bottle, of 50 cubic inches capacity, we filled it at the main spring. The water instantaneously turned of a pale red; but after having stood at rest, for one hour, a purple-red, extremely light, woolly, slocculent sediment subsided, which left the superincumbent liquor clear and colourless.

Another bottle, in which one grain of pulverized pure Prussian alkali had been placed, when likewise filled at the spring itself, shewed no change or indication of colour. But some minutes after, when we instilled some drops of nitric acid to saturate the predominant soda, the blue colour appeared by degrees; so that, at length, the water was uniformly tinged blue by it.

The following experiments convinced us, how necessary it is to perform these trials at the spring itself. We had ordered a jug, recently filled, at the main-spring, and closely stopped, to be brought to our lodgings; where we immediate

ately, and before the temperature of the water had been fenfibly lowered, examined it by means of galls, and tincture of galls. But it remained for a while colourless; only, by degrees, it inclined a little to a feeble, turbid olive-green; and when afterwards a few drops of nitric acid had been added, the colour passed into a shade of a dilute blueish-black.

But when the water from the main-fpring had cooled more confiderably, it was no more possible to produce, by any means, any change of colour, or indication of iron.

The water of the new spring afforded the same phenomena as that of the main-spring; that is to say, when the bottle, into which the re-agents had been previously introduced, was filled at the spring itself, the water became coloured, and shewed its ferruginous contents. But when conveyed to our apartment, in well closed bottles, it was tinged in some degree, while its original temperature continued; but as soon as the water began to cool, no trace of colour could then be any longer discovered.

On the contrary, the water from the spring at the castle, though likewise taken at the spring itself, and there examined, suffered no change at all.

It now remained to investigate the other fixed constituent parts: for this purpose, we gradually evaporated, with a gentle heat, one hundred cubic inches of water, freshly taken from each of those three springs, down to some ounces.

We then separated, by means of filtration, from these refidues, thus reduced by evaporation, the earthy parts from the faline, that were yet held in solution by the water, and washed and dried them. This earthly portion consisted of carbonated line, mixed with filiceous earth, and a slight trace of iron. By digeffing it with muriatic acid, the lime and the iron diffolved, and, on the filter, we obtained the filex alone, in a loofe, flimy state. The muriatic solution we treated, at first, with prussiat of pot-ash, and there immediately appeared blue flocculent particles: however, it was only after some days that they formed a solid precipitate. When the supernatant liquors had again become clear and colourless, and the precipitate had been separated upon the filter, we precipitated the calcareous earth from each of them by carbonated ammoniac, edulcorated, and dried it.

We now proceeded to separate the salts combined in those folutions. Taught by experience, that heterogeneous salts, existing in one common menstruum, can but seldom be separated, by crystallization, with due accuracy, especially in small experiments, we adopted another more certain method; namely, by saturating, first, the uncombined soda by an acid, and decomposing afterwards the neutral salts by proper substances. At the same time, by other previous experiments, we had discovered and ascertained the proportions of the ingredients in salts of the same nature, to be enabled thereby to calculate those results.

These last mentioned experiments, serving as standard measures in the present pursuit, were principally as follows.

- a) Thousand grains of soda, recently crystallized and weighed, after drying on printing-paper, lost, when completely desiccated on the sand-bath, 637 grains of weight. Thousand parts of soda in the state of crystallization, therefore, are equal to 363 parts of the same alkali, reduced to a powder by a thorough exsiccation effected by means of heat.
- b) Hundred grains of the fame foda, deprived by heat of its water of crystallization, required, for their faturation,

382 grains of fulphuric acid, composed of a mixture of one part of that acid, rectified, and of 1,850 specific gravity, with three parts of distilled water.

- c) The fulphat of foda, obtained by this faturation, and completely dried, by evaporating in a fand heat, weighed 132½ grains.
- d) One thousand grains of sulphat of soda, recently crystallized and dried on printing-paper, when exsiccated to the most in a fand-heat, weighed 420 grains.
- e) Hundred grainsof the above-mentioned glauber-falt, diffolved in water, and decomposed by an acetic solution of barytes, gave 168 grains of washed and dried sulphat of barytes, or regenerated ponderous spar. Thousand parts of the latter, therefore, contain a portion of sulphuric acid equal to 595<sup>1</sup>/<sub>4</sub> of sulphated soda, that has been deprived by heat of its water of crystallization.
- f) One hundred grains of common falt in crystals, dried in the air, dissolved in water, and decomposed by a nitric solution of silver, yielded 233½ grains of edulcorated and dried muriat of silver, or precipitated hornsilver, as it is called. Whence the quantity of muriatic acid, contained in 1000 parts of this last, is equal to 428½ parts of pure and dry muriat of soda.

Affifted by these discoveries, we could now, with certainty, expect the success of our attempt without danger of error, by making a proper use of them. Thus we first investigated the quantity of free or carbonated soda, by adding to every one of those solutions as much of an accurately weighed quantity of sulphuric acid, of the specific gravity mentioned, (b) as was necessary to a complete saturation,

and from the portions of the acid employed in these processes, we computed the quantity of the alkali contained in each of the solutions.

This done, we combined the muriatic folutions with diffolved acetate of barytes, until all precipitation ceased. From the weight of the barytic fulphat then generated, we calculated the quantity of sulphated soda: having, before, subtracted that portion of it, which had been produced by the saturation of the uncombined soda, and united with the glauber-salt, naturally contained in the spring.

At last, we decomposed the common salt, lest in the solutions after the separation of the barytic sulphat, by means of a nitrated solution of silver; and we computed the quantity of that muriated soda from the hornsilver, obtained by the process.

It refulted from these experiments, that

A) Hundred cubic inches of water from the main-spring, at Carlsbad, contain:

Dry carbonated soda	39 grains.
(or, in crystalline state, 107½ gr.)  Dry native sulphat of soda	70±
(or, in crystals, 168 gr.)	7 2
Muriat of soda	
Silex	
Oxyd of iron, about	1 3
Total	1583 gr.

Carbonic acid gas, 32 cubic inches.

B) Hundred cubic inches of the water, taken from the new-spring, contain:

1	Dry Carbonat of foda 38½ grains.
	(or, crystallized, 106 gr.)
	Dry native sulphated soda 663
	(or, crystallized, 159 gr.)
	Muriat of Soda $32\frac{1}{2}$
	Carbonat of lime 123
	Siliceous earth 21
	Oxyd of iron, hardly

Total . . 152 grains.

Carbonic acid gas, 50 cubic inches.

C) And lastly, an hundred cubic inches of water from the spring at the castle yielded,

Dry corbonat of soda 37½ grains.
(or, in crystals, 103½ gr.)
Dry fulphated foda $66\frac{1}{2}$
(or, in crystals, 158 gr.)
Muriat of soda
Carbonat of Lime 123
Silex $2\frac{1}{8}$
Oxyd of iron, hardly

Total . . 151 15 grains.

Carbonic acid gas, 53 cubic inches.

In order to enable any person to reduce these constituent parts to certain weights, or to other liquid measures of the mineral water, I will mention, that the cubic inch, which, in these these experiments, has been made the standard, is equivalent to 290 grains of distilled water, (of the genuine medicinal weight of Nurenberg\*). The above 100 cubic inches, therefore, with respect to their solid capacity, are equal to  $60\frac{5}{12}$  ounces of water.

On comparing the fixed conflituent parts, discovered by Count Gessler and myself, with those given by Dr. Becher, I shall notice merely the water of the main-spring. The quantity of it, which he employed, in every instance, was fix pounds medicinal weight. Dr. Becher observes, that he means the old apothecary's weight and measures, formerly used there; which is, to that now introduced, as 12 to 14; but I suppose that the above is the same with the usual medicinal weight, of 12 ounces, or 5760 grains. Therefore, by calculating, according to these data, the dry refidue which we should have obtained from 6 lb. medicinal weight, or from 1195 cubic inches of water from the mainfpring, would have amounted to 18917 grains; and this very nearly agrees with the 192 grains obtained by Dr. B.; the difference of 2110 being very unimportant, especially as he himself has also obtained three drachms, or 180 grains less of this dry residue from an equal quantity of the mainfpring water. With regard to the proportion of the fixed parts to one another, Dr. Becher thinks that the feveral constituent ingredients, in those 192 grains, may be divided in the following manner:

Dry soda		
Sulphat of Soda		93
Muriat of Soaa .		26
Calcareous earth .		201

<sup>\*</sup> Or 2784 grains, English Troy, very nearly. Transl.

But, according to the result of our experiments, the above-mentioned 192 grains of the residue of the water from the main-spring would afford,

Dried soda				47 <sup>‡</sup> grai	ins.
- Sulphat of Sodo	70			854	3 4
Muriat of soda .				42	
Calcareous earth			4	141	42/12
Siliceous earth .				3	

To explain these variations, besides first repeating the observation before mentioned, that in mineral waters the proportion of the ingredients is not, at all times, invariably the same, I believe the following remark may be of some affishance in elucidating the difference.

- a) Dr. Becher procured the foda, which he used in his preparatory experiment, by diffolying, in water, the calcined refidue of the deficcated mother-water; and, having crystallized it, he confidered the falt obtained, at the third shooting, as pure mineral alkali, and employed it accordingly. This, however, cannot eafily be prefumed to have been perfectly pure, but was probably still mixed with some common falt; which supposition seems to be strengthened by the figure of the crystals, described as minute-grained and needle-shaped. On every account it would, indeed, have been not superfluous to have tried, before-hand, by experiments, the purity of the foda, and the total absence of all neutral saline admixtures. For, in proportion as the foda employed in the comparative experiment was still rendered impure, by any foreign falt, in the same ratio must the calculation, sounded upon it, have given an excess of soda above the true quantity which enters into the water of the fpring.
- b) That the portion of common falt was found to be much less by Dr. Becher, than by us, arises from the uncertain method

method which he has employed to separate the sulphat and muriat of soda, by mere crystallization; since the former, especially in the last shootings, always attracts to itself a portion of the latter, which accompanies it in the lye. Therefore,

- c) The proportion of the neutral fulphat of the spring, as determined by calculation, must, for the same reason, have appeared greater than it really is.
- d) The filiceous ingredient in the water of Carlsbad has entirely escaped the attention of Dr. Becher, as it did other authors, who treat of this spring. This, however, may be excused, because silex has been formerly considered as a substance totally insoluble in water, and, therefore, has never been suspected to be a constituent part of mineral springs. But it cannot be allowed that this earth is only casually admixed with the water, and floats in it as a fine sand; for, that it exists in it in an actual state of solution, is evident, from the swelled, slimy, and transparent state in which it remains after the solution of the calcareous earth.

Nevertheless, this quantity of siliceous earth, in Carlsbad water, whose solvent power over this earth is aided by its temperature, great as it may appear, with regard to other mineral springs, is, in fact, but inconsiderable, when compared with the silex, contained in a much larger portion, in other hot springs; the Geyser, for instance, in Iceland. But it must also be observed, that the temperature of this last so far exceeds that of Carlsbad, that, according to Troil's testimony, even when this immense jet of 19 feet in diameter had risen, as it often does, to the height of 90 feet, its water is still found perfectly boiling hot, when it again comes down to the ground.

I shall

I shall now give an estimate of the quantities of the constituent parts of the water of Carlsbad, taken by its visitors. The mean number of cups which are drank is 14 in the day, as the daily allowance is from 10 to 18; the immoderate quantity of 30 or 40 cups, and upwards, which were formerly taken, being now laid aside: one of these cups, upon an average, holds nearly 10 cubic inches of water; and, therefore, will hold 140 cubic inches, which contain:

Crystallized carbonated soda	. 150½ grains.
- Sulphat of Soda	. 228
Muriat of Soda ,	. 48
Calcareous earth	. 1713
Siliceous earth	31
Oxyd of iron	. 4

Garbonic acid gas, 45 cubic inches.

The time usually spent in the medicinal use of this spring is from three to sive weeks. If, therefore, we assume, at a mean rate, 26 days for the whole of that time, and calculate by it the quantity of water drank by each patient, it will be found to amount to 364 cups, holding 3640 cubic inches of the mineral water, which contain,

Crystallized corbonat of soda		3913 grains.
- Julphat of soda		5928
Muriated soda		1248
Calcareous earth		450
Siliceous earth		91
Oxyd of iron		6 <u>±</u>

Carbonic acid gas, 1170 cubic inches.

It is not my province to speak of the medicinal effects of the mineral spring at Carlsbad. On this subject various celecelebrated yficians and writers, as Fred. Hoffmann, Tralles, Springsfeld, Zückert, and in particular Dr. Becher, the respectable author of the above-mentioned Description of Carlsbad, have given sufficient information and instruction.

On one point, however, I shall briefly touch. Many perfons, less versed in chemistry, are of opinion, that the native glauber-falt of this mineral fpring is effentially different from, and preferable to any other fulphat of foda; upon the ground, that a moderate quantity of the water, for instance 14 cups, in which that neutral falt, calculated in the crystalline state, amounts only to 228 grains, or 12 grains less than half an ounce, is found to possess a greater aperient power than any other artificial glauber-falt, though taken in greater proportion. But in this statement, which is confirmed by experience, we should not forget to have due regard to the influence of the foda; because the alkaline substances and earths are converted into neutral or middle falts, in the stomach and first passages, whenever, as is mostly the case, any acid there predominates, and they thus acquire the cathartic properties of other purging falts. Nay, it is probable that it is owing to this constituent part of the Carlsbad water that feveral perfons, whose humours in the ftomach and first passages are, perhaps, more disposed to alkalescence than acidity, often experience, on its internal use, effects quite contrary to those which they expected from its opening power. Moreover, the filiceous ingredient may be frequently an acceffory cause of the unpleasant effects on the bowels, which the water produces in those persons in whom the peristaltic motion is rather languid.

However, these, as well as all other medical remarks, I leave to the physicians, and will allow to myself only some reflections concerning the substances, which Nature employs to impregnate the Carlsbad mineral spring with the abovementioned

mentioned ingredients, and concerning the manner in which, perhaps, it operates in this process. I say, perhaps, for the searching mind of man is not endowed with the faculty of inspecting the interior and secret recesses of the laboratory of Nature, without danger of error. All that we are able to do, is to suspect, and to draw probable conjectures from phenomena similar to those, which we have had opportunity of perceiving either in the operations of Nature herself, or in our small chemical experiments.

The cause which produces the heat in the springs at Carlsbad is variously stated by philosophers. The opinion of a great fire, supposed to exist in the centre of the globe, to which, formerly, all the great phenomena in the fubterraneous laboratory of Nature, and hence also the generation of hot mineral springs, have been ascribed, has, at present, scarcely any supporter. Others would account for that cause by the volcanos, which are faid to have once existed in that country, and, though burned out on the furface, are not yet perfectly extinguished beneath. But this, likewise, is an ill-founded hypothesis; as neither a true crater, nor what might have once been the fire-gulph of a volcano, nor any undoubted lavas and other matters ejected from it, can be found there. In fact, the earthy scorize, met with in the vicinity of Carlsbad are not of a true volcanic origin; and as little may the basalts, which are there met with, be comfidered as an additional proof of the volcanic nature of that country.

Those naturalists seem to come nearer to truth, who trace the efficient cause of heat in these springs from ignited sulphur-pyrites. With this opinion, likewise, the celebrated author of the Treatise on Carlsbad Water coincides, when explaining the temperature of its springs. And, indeed, it cannot be denied, that pyrites act their part in this case.

For

For the stratum of pyrites, which is only a few miles distant from Carlsbad, and from which the sulphur and vitriol-works at Altsattel are plentifully provided with that crude material; besides, the siliceous ingredient disseminated in the stony mixture of that stratum, under which, according to all indications, that subterraneous laboratory lies where Nature prepares the mineral water; and, lastly, those constituent parts of these mineral springs, the origin of which we cannot explain from other substances besides from sulphur-pyrites: all these circumstances coincide to give weight to that opinion.

Yet, on a maturer confideration, it will foon be evident, that the diffolved pyrites could not alone afford that quantity of caloric, which has heated the fprings at Carlsbad, for feveral centuries past to this day, with unabated force; but, on the contrary, that, to the production and preservation of natural hot springs in general, another combustible matter is required, from which the subterraneous fire receives its food. And thus it will be obvious, that this suel can be nothing else but mineral coal, that remainder of vegetable fragments of the ancient world, locked up in the bosom of the earth, which provident Nature has wisely reserved.

When a subterraneous store of mineral coal, such as occur in various places in strata, of an enormous thickness, has been once set on fire, by ignited pyrites or other causes (as may easily happen, especially where the stratum comes out near to the day) the inflammation will then spread throughout the whole remaining mass, with a quicker or slower progress. A spontaneous extinction and complete refrigeration can certainly not be very soon expected in that case; for the larger the bulk of a burning body is, the longer will the heat, excited by it, continue. If, besides, it is considered, that this immense mass may possibly be inclosed by walls of rocks,

rocks, impenetrable, and little capable of conducting heat, at the same time that the air finds access to it in but a very small degree; it is then easy to conceive, that ages must pass before the caloric disengaged from such an immense mass can be fixed again, and brought to a state of equilibrium with the whole.

But that a mine of mineral coal had once been burning at Carlsbad is a fact, unquestionably proved by the earthy scorize that have been erroneously taken for genuine volcanic lavas, by the porcelain-jaspers, and by the other species of stones and earths, more or less changed by fire, covering the fields at Hobdorf, Lessa, and other places, in copious quantity, many of which perfectly resemble the pseudo-volcanic products of various countries; such, for instance, as the stratum of mineral coal even now burning at Dutt-weiler, near Saarbrück.

Carlsbad, which is fituated in a narrow, longish valley, is on all sides surrounded by mountains of the middle size; which, however, little cohere among themselves. These mostly consist of granites, of which that variety is the most predominant, which consists of much, large, yellowish, white rhomboic fel-spar, with small black micaceous scales, and a little fine grained quarz.

But, close to the Hirschenstein, the highest of those mountains, and situated south of the town, there stretches from the Guildhall to the Bernhards-rock another range of low mountains, which cannot properly be considered as primitive granite, but rather as a rock of later formation: since it exhibits a stony mass, a second time formed of fragments of the primeval rock, and consisting of a granitic mass of stones, finely grained and rifty, passing into a porphyraceous mixture, with finely interspersed pyrites. It is the

common

common opinion, which is also supported by various local circumstances, that underneath this mountainous range, the laboratory lies, where Nature produces that beneficial spring. For, not only does the vaulted roof of the bason, or reservoir of the main-spring, (the breadth of which extends from the Guildhall, along and under the market-place, as well as under the bed of the river Töpel, to the church) proceed from the foot of that low rock, but also all the other springs issue from it; besides, that the warm mineral water oozes out from several other of its sissues and veins. But, if this stony matter is granted to be of secondary formation, and not a primitive rock, the possibility of a mighty stratum of mineral coal, lying under it, can no longer be questioned.

Now, concerning the generation and origin of those conflituent parts, with which this hot water is impregnated, and thereby ennobled to the rank of a medicinal spring; these depend on the very same laws of nature, which chemistry has learnt by experiments to be such, and by which it is guided in imitating the operations of Nature in the small way. Yet, our knowledge, it must be confessed, is not always sufficient to comprehend, accurately and distinctly, the method which Nature employs in every particular instance. Nature, in her great operations, always proceeds in a simple way; whereas, we being but humble imitators of that great mistress of chemistry, cannot help resorting to artificial, and thence imperfect processes, whenever we attempt to obtain the same products from the same principles.

First, as to the origin of the carbonic acid in the water of Carlsbad, the opinion of the author of the Neue Bemerkungen über das Carlsbad, who deduces the gas of that spring from the sulphur-pyrites themselves, cannot subsist;

for,

for, what is extricated from mouldering pyrites is not the carbonic, but the fulphureous acid, combined, according to circumstances, with hydrogen gas. On the contrary, it admits of no doubt, but that limestone is the principle, which in all cases, and hence in this also, affords the carbonic acid. From the fact already related, that the rock feated upon the laboratory of this spring is of a younger date, and later formation; it is certain that limestone may be prefent at some depth; whether it confift of primitive calcareous rock, or of stratified calcareous stones; and that it actually and necessarily there exists, is manifest from this very daily generation of fo great a quantity of carbonic acid. But, whether the developement of this elastic acid from the limestone is effected merely by the heat, or by means of the sulphuric acid, disengaged from the dissolved pyrites, is a question which cannot be positively answered. It is, however, probable, that it is expelled by heat alone.

With regard to the generation of the neutral fulphat, or the glauber-falt, it undoubtedly cannot take place, but when veins of common falt come into contract with diffolved fulphur-pyrites. Part of the muriated foda is then decomposed by the fulphuric acid, and unites with it to a new neutral falt, viz. the native glauber-falt, or sulphat of soda.

And, as the existence of carbonic acid in the Carlsbad water necessarily presupposes the presence of a calcareous stratum; the enquiry into the origin of the calcareous earth, dissolved in this mineral spring, is answered of itself. It is by the spontaneous separation of that earth from the water, that the above-mentioned wonderful stone-vault, of the great reservoir, together with the remaining vast quantity of variously formed stalactites and tusas, have been produced, and are daily augmented. Therefore, it is not necessary to search in vain, with Dr. Becher, and against all rules.

rules, for the origin of the calcareous earth in the mixture of the pyrites; nor to lay any stress on the small quantity, which might be an accidental ingredient in the muriated brine, employed by Nature in the production of the mineral springs at Carlsbad.

But we cannot judge with equal certainty of the method followed by Nature, in generating the uncombined foda exifting in the Carlsbad water; fince, of all the methods, which we are able to employ for the fame purpose, there is none of such a kind that we could fairly suppose to be applied in the operations of Nature, who always accomplishes her ends by the shortest ways. It is probable that a long continued influence of the subterraneous heat, and humid vapours, are alone sufficient to volatilize part of the muriatic acid of the muriated soda, leaving behind the alkaline principle that had been united with it.

On this predominant portion of free foda also depends in part the peculiar taste of Carlsbad water, which, when drank warm, may be compared to a weak meat-broth.

Sulphur-pyrites, mineral coal, limestone, and brine-springs of muriated soda, are, therefore, the raw materials made use of by Nature in elaborating those hot mineral springs. How enormous the store of them must be, may be conceived by reslecting upon the quantity of water, and its ingredients, which is afforded by the main-spring alone, in the course of one year. By the computations of Dr. Becher, there issue 705 eimers in an hour, from the sive orifices of that spring; which makes, for one day, 16,920; and hence, for the year, 6,175,800 eimers. And, if the eimer be taken to be equal to one half cubic foot, that quantity amounts to 3,087,900 cubic feet of water. These contain:

		Pou	nds	avardupois	04
Crystallizable soda		+ .		746,884	
	of Joda		Ι,	132,923	
Muriat of Soda .				238,209	
Calcareous earth .				86,020	
Siliceous earth .				17,369	
Oxyd of iron				1,240	

Carbonic acid gas 992,539 cubic feet.

And, fince the quantity of water yielded by the newfpring, by that at the mill, and by the other streamlets issuing from the clefts of the rifty rock, taken together, may be estimated as equal to that afforded solely by the mainspring; our astonishment is justly excited, on considering the immense quantity of products which have been sent forth by those springs at Carlsbad, within a term of 420 years; that is, from 1370, which is the period assumed in history for their discovery, to 1790.

Yet, no other use is made of the great quantity of saline contents with which Nature has enriched the Carlsbad-mineral springs; except, that yearly, several hundred pounds of sulphated soda are obtained in the crystallized state, by evaporation, and sold by the name of Carlsbad-salt. But it would be an object deserving the exertions of industry, if, at the same time, pains were taken to recover and employ one part of mineral alkali, or soda; instead of suffering so many thousand pounds of that natural product, so valuable with respect to our present wants, to be unemployed, and carried away into the river Töpel.

Before I conclude, I shall say a few words on a cold acidulous spring, which is met with behind the brew-house, in a granitic rock. This spring collects in a small shallow bason, situated on the declivity of the rock, and is richly impreg-

impregnated with carbonic acid, that penetrates through the bottom of the bason, and covers the fluid in a stratum from four to six inches thick. Its taste is so exceedingly sour, that a doubt has arisen, whether that acidity depends merely on the proportion of the carbonic acid. But experiments have shewn it to contain no other extraneous acid; and the quantity of carbonic acid gas was found to be equal in volume to that of the water itself, where 18 cubic inches of water have yielded 18 cubic inches of the gas. This acidulous spring hardly contains any fixed constituent ingredients: for, when a considerable quantity of it has been evaporated by the assistance of heat, a residue was indeed left, which proved to be a neutral muriat, but so small, as almost to escape observation.

This valuable, but, at Carlsbad, little efteemed spring, methinks, deserves to be protected against the casual impurities by which it is now liable to be defiled, by a more suitable inclosure and careful covering; as well as to be more commonly applied, both for medicinal and economical purposes.

#### XXVI.

### CHEMICAL EXAMINATION

OF THE

# SALT-SPRINGS AT KÖNIGSBORN,

And their Products \*.

HE faline fprings, among others, chiefly belong to those objects, with the investigation of which the industry of chemists has been hitherto but little occupied. This want of a more folid and complete knowledge of the conflituent parts of the faline springs cannot fail to have occasioned a number of erroneous processes in the falt-works; and, the necessity of abolishing or correcting them, is in general fuggested only by the loss experienced for many years. How many errors would have been avoided in the calculations and estimates, if, for instance, instead of employing the bydrometer, that deceitful, empirical scale, which hitherto has been almost alone resorted to, and trusted, in ascertaining the proportion of falt contained in any brine, the falt-makers had been able to proceed upon the ground of a more certain knowledge, founded on chemical analysis, of the true saline portion, as well as of the other foreign substances, which are the habitual concomitants of common falt? For this reason, I believe, that by publishing the prefent inquiry into the faline springs, and their various products, of the falt-works at Königsborn, near Unna,

<sup>\*</sup> Sammlung der Deutschen Abhandlungen der Königlichen Academie der Wissenschaften. Berlin, 1794.

in Westphalia, I am contributing, perhaps, not an unimportant share to a general chemical knowledge of saline springs.

The faliniferous mountain at Königsborn confifts of a compact, marly limestone, separated in strata, and disintegrable in the air, which seem to rest immediately upon the fand-stone, or red dead rock\*. They extend in a direction from east to west, from Paderborn, between the river Lippe and Emsche, as far as the dukedom of Cleves; and they decline, from southwest to northwest, into the bishopric of Münster, where they are covered by strata of fand and loam. The salt-springs at Salzsotten, Westrinkotte, Werle, Sassendorf, and Unna, which have been used for many centuries past, and several indications of a weak brine, near Bochum, in the Dortmundt territory, &c. are likewise situated on the same mountains.

The prefent falt-work at Königsborn lies about one mile (English) distant from Unna, to the north, in a plain; accompanied on both sides by gentle elevations. Wherever the ground is perforated or dug, at and below Königsborn, towards the north, there are always salt-springs found; but above Königsborn, southwards, springs of sweet water exist, which come forth to the day, and even will rise in pipes to 10 or 12 feet. On this account, the brine has been procured, for many years past, by means of such perfora-

<sup>\*</sup> By the dead rock is understood the stone, or substance, which lies between the primary and secondary strata, and participates of the nature of both. The Germans call it todt-liegendes; Kirwan calls it semiprotolite, and likewise deadlier. See his Geological Essays. Lond. 1799. page 225; and his Elements of Mineralogy. Lond. 1794. vol. i. page 363.—Trans.

tions, of which there have been more than twenty, of a depth from 75 to 280 feet. The brine obtained from these, at a depth from 50 to 80 feet, always contains from 11 to two ounces of falt in the pound; that from 80 to 120 feet, contains 23 ounces; but that from 120 to 200 feet, affords 31, and even 31 ounces; and it is pumped up to the height of 12 feet above the furface, by means of the above-mentioned wooden pipes, in a quantity amounting to from three to four cubic feet every minute. Experience has shewn, that this faline spring has decreased in dry weather, in quantity of water, and richness of falt; but has increased, in both respects, in wet weather, or when in the midst of summer it has rained only a few days, after a great drought. However, after the lapse of four or fix years, the brine has been fo much impoverished, at every well, as to yield only 11 ounce of falt; although neither the quantity flowing out had increased, nor had the brine been otherwise altered. As often, therefore, as this happened, a new perforation has been made, by which means a brine, 3 or 31 ounces, rich in falt, was again obtained for fome time. From this account it would feem, that there exist three distinct faltfprings lying upon each other; that the deepest are the richest; which, therefore, by their rising, force away the upper and lighter ones; and, that these last must be in conjunction with some stream, the sweet water of which washes a mass of falt, and thereby becomes impregnated with part of it. Hence may be explained the rapid increase of the quantity of the fluid, and of its proportion of falt, after rainy weather. In consequence of this conjecture, some years ago, shafts were funk between the several borings; the lighter springs were stopped up, and the richest were brought out to the day. However, the event was, that by means of this perforation, at the IIIth foot in depth, a copious fpring was come at, but only one ounce in richness; which poured into the well, that was already 60 feet deep,

deep, in fuch quantities, that at every minute 25 cubic feet were to be overcome. On the very day that this fpring had been pierced, the faline contents in the feveral brines augmented in all the wells, from  $1\frac{1}{4}$  ounce to  $1\frac{1}{2}$ , 2, and even  $2\frac{1}{4}$  ounces. This weak brine, therefore, feems to impoverish the richer ones, by penetrating through the fissures of the marly rock to the perforated cavities; and either keeping off the deeper springs of 3 ounces richness in salt, or mixing with, and thus lowering them down to 1 and  $1\frac{1}{2}$  ounce.

To shew what quantity of salt may be procured from these springs, I shall select the period of three years; namely, from the 1st of June, 1788, to the last of May, 1791. During that time were procured:

35,521,534 pounds.

This gives for one year:

11,850,5114 pounds.

By taking into the calculation the loss occasioned by the boiling, which has been ascertained by actual experiment, as well as the loss arising from the graduation \*; which, by estimation, is reckoned at 37 per cent, there will be required of the brine, to obtain the above produce in each year:

336,069,731 pounds; or, 4,972,748; cubic feet.

<sup>\*</sup> In other words: from evaporating the brine by means of air, previous to their boilings, in particular buildings, called graduating-bouses. Consult Gren's Principles of Modern Chemistry. Lond. 1800. vol. i. page 294.—Transl.

## 302 XXVI. Chemical Examination of the

In speaking of the chemical examination of those springs; to avoid unnecessary repetitions, I shall only in general explain the method in which I have proceeded in this inquiry; and, with respect to each particular spring, &c. I shall merely state the result of my experiments:

- t.) In order to determine the specific gravity of each brine, I measured 50 cubic inches (each equal to 290 grains of distilled water); weighed, and compared them with the weight of an equal quantity of distilled water.
- 2.) These 50 cubic inches of brine were then evaporated, in a fand-heat, to a dry residue, and the weight of it noted.
- 3.) These residues were then covered in cylindrical glass-vessels, with alkohol, and extracted by means of it during 24 hours, at a moderate temperature, and with repeated stirring.
- 4.) After the alkohol had been again separated by filtration, it was evaporated to dryness. Upon the residue lest by it, fresh ardent spirit was affused, in such a quantity as was necessary to separate the small portion of common salt, which had united with the spirituous solution, at the first extraction. After this, the last alkohol was likewise evaporated, and the residue weighed.
- 5.) That portion which had been extracted by alkohol confifted of muriat of lime, mixed with a very trifling portion of muriated magnefia; the proportion of which last was determined in the following manner:—The refidue, obtained by the evaporation of the alkohol, was diffolved in water, the folution heated, and the earth precipitated by foda. This earth, when washed, was combined with sulphuric acid, added in excess. After the mixture had stood

for

for a while in a warm place, and the predominant acid had been again abforbed by carbonat of lime, which was added for this purpose, the liquor was freed from the selenite or gypsum then generated, and evaporated by a gentle heat. When the selenite, which still appeared, was again separated, and the liquor sufficiently reduced, the solution was exposed to spontaneous exhalation in the open air, and thus made to crystallize. The sulphat of magnesia, produced by this process, was redissolved in water, and decomposed by soda; upon which the magnesia, which separated, was saturated with muriatic acid, evaporated to dryness; and the weight of this muriated magnesia subtracted from the muriated lime.

- 6.) The deficcated muriat of foda, remaining after the feparation of those deliquescent salts, by means of alkohol, was next dissolved in water, and filtered.
- 7.) The remainder on the filter confifted of fulphat and carbonat of lime; and in some, brines of oxyd of iron.—When weighed, it was treated with muriatic acid, and the selenite separated upon the filter. The filtered solution, when it appeared to contain a separable portion of iron, was combined with caustic ammoniac; and the oxyd of iron, which fell down as a brown slocculent precipitate, when collected by the filter and ignited, was weighed, and its weight reduced to that of carbonated iron.
- 8.) I combined the muriatic folution of No. 6 with carbonat of foda, affifted by heat, when a precipitate enfued, confifting of carbonated lime. The foda, employed for its precipitation, having thus been again neutralized by the muriatic acid, I treated this muriatic folution with muriated barytes. From the fulphat of barytes, obtained by this management, it was obvious that the calcareous earth precipitated,

precipitated, by the carbonated foda, from the diffolved muriat of foda, had been combined with fulphuric acid in the character of felenite. In like manner, it followed from the proportion, which the quantity of fulphuric acid bore to the calcareous earth, obtained in a state of combination with it, that the muriatic folution contained felenite only, and no glauber-falt, nor any other alkaline or earthy fulphat. The total absence of these last was also confirmed by this; that the dry salt gradually dissolved in a mixture of two parts of alkohol with one of water, which I affused upon it; and, that at last nothing but selenite remained.

The experiments, performed in the manner here explained, gave the following refults:

#### A.

## Brine of the Varsthauser-spring.

Its specific gravity was 1039 (distilled water being 1000).

Fifty cubic inches, evaporated to dryness, afforded a greywhite residue, weighing 882 grains.

This refidue confisted of:

Muriat of lime .		46 grains.
magnefia		I
Carbonat of lime .		. 12
Selenite, or sulphat of	f lime	. 25
Muriat of soda .		. 798
		882

B.

## Brine of the Glückauf-Spring.

Its specific gravity was found to be 1029.

Fifty cubic inches left a pale-red refidue of 585 grains, containing:

Muriat of lime	32	grains.
of magnesia	1	" und
Carbonat of lime	II	
Carbonated oxyd of iron .		
Selenite	18	
Muriat of soda, or common salt	522	
	585	

C

# Brine of the Frederic-anton-spring.

Its specific gravity was 1025.

Fifty cubic inches left, by evaporation, 540 grains, of a light-reddiff refidue, confifting of:

Muriated lime, including a scarcely ob- servable trace of muriated magnesia	20 grains.
Carbonated lime, or crude calcareous earth	111
oxyd of iron	<u>I</u>
Selenite, or gypsum	14
Muriated soda	494
· · · · · · · · · · · · · · · · · · ·	540

D.

# Brine of the Goldener Sonnen-Spring.

The specific gravity was 1024.

The dry refidue, yielded by 50 cubic inches, had a light-grey-white colour, and weighed 521 grains. It was refolved into:

Muriat of lime	. 30 grains.
of magnesia	(.) 1 1 1 1 ( ) 1
Carbonat of lime	. II
Selenite	. 15
Muriat of Soda	464 <u>I</u>
Best Water	
を を を を を を を を を を を を を を を を を を を	FOT

E.

# Brine of the Ludwigs-springs.

Its specific gravity 1023.

The light-reddish residue, from 50 cubic inches of the evaporated brine, weighed 508 grains, and contained:

Muriat of lime	20 grains.
Carbonated lime	10
- oxyd of iron	<u>I</u>
Selenite	13
Common falt, or muriated foda	464 ½
The state of the s	
	508

The

The brine, which is brought up from the various faltfprings, is conducted into one common refervoir, from which it is pumped to the top of the graduating-houses, where it is three times graduated.

F

# Brine of the first graduation.

Its specific gravity rose to 1060. The residue from the evaporation of 50 cubic inches weighed 1285 grains; and consisted of:

Muriated lime	65 grains.
— magnefia	$I^{\frac{1}{2}}$
Carbonated lime, containing fome iron	4 <u>1</u>
Sulphated lime, or felenite	44
Muriated soda	1170
	1285

G.

# Brine of the second graduation.

Specific gravity 1076.

Fifty cubic inches, evaporated, gave a refidue of 1615 grains. This was decomposed into:

Muriat of lime .				75	grains.
of magnesia			•	2	
Carbonat of lime				3	
Selenite	-		.00	48	
Muriat of Soda .			1	487	
			1	615	braing ?

H.

H.

Brine of the third graduation.

Its specific gravity amounted to 1086.

Fifty cubic inches of it have left, upon evaporation, 1850 grains of a dry refidue, containing:

Muriat of lime .			. 82	grains.
- of magnefia				
Carbonat of lime .	70		. 3	
Sulphat of lime (se	lenite)		. 52	
Muriat of Soda (co	mmon	falt) .	. 1710	
			-	
			1850	)

The falt obtained by boiling from these graduated brines is of two forts, of which the one is destined for foreign, and the other for home consumption. The first consists, for the most part, of considerably large, four-sided, hollow crystals, composed, in a funnel-like manner, of simple cubes of muriated soda. Such crystals are always formed on the surface of the brine, when they can evaporate without agitation. The second sort is externally distinguished from the preceding by somewhat smaller and less regular crystals.

T.

Common falt for exportation.

One pound of it, that had been completely deficcated with the affishance of heat, was pulverized, and then

examined by the method above-described. It confisted of:

	Oz.	drach.	gr.
Moisture, expelled by the drying		3	-
Accidental impurities, and fand .	· within	Sanday .	10
Muriated lime	-	_	25
Selenite	1 1203	I a	30
Pure muriat of soda	. 15	2	55
- Norman	16	Ounces	

### K.

## Common falt for home-confumption.

One pound of it, treated as the last, contained:

	Oz.	drach.	gr.
Moisture	-	4	30
Accidental impurities	-	-	18
Muriated lime	-	esertion and	30
Selenite	-	1	35
Pure muriat of soda	15	O FOR	7
at of feet The question water of		Vitra IN a	house

16 Ounces.

#### L.

# Mother-water,

The mother-brine proved to be of confiderable specific gravity; namely, 1218.

Fifty cubic inches of it, when evaporated, yielded 5440 grains of dry falt, which I divided into two parts, subjecting each to a separate examination.

## 310 - XXVI. Chemical Examination of the

1) 2720 grains, or one half of the falt obtained from the mother-water, and decomposed after the manner so often mentioned, gave:

Muriated calcareous earth	hins		12	330	grains.
- magnefian earth				420	
Sulphated calcareous earth		•		50	a stime!
Common salt	7			1920	
16 Ounces.			-	2720	

2) The other half of the falt, afforded by 50 cubic inches of the mother-water, I re-diffolved in water, and evaporated the folution to the point of crystallization. I obtained from it, at five successive shootings, 4 ounces and 2 drachms of crystallized muriated soda, but which was still contaminated by the mother-water which adhered. For this reason, I dissolved it once more in water, and crystallized it anew; by which treatment I then obtained 3 oz. 7 dr. of pure common falt. By this it was rendered evident, that every cubic foot of that mother-water, if treated in the fimple way of crystallization, would still afford 16 or 17 pounds of pure muriat of foda. The mother-water of both crystallizations was diluted with water, and its earthy portion, precipitated by foda, weighed 544 grains, when washed and ignited. This precipitate confished of calcareous and magnefian earth; which I feparated, by faturating the mass with fulphuric acid. When the fulphat of magnefia had been filtered off from the sulphat of lime which was formed at the fame time, I decomposed it by means of soda. The magnesia, then obtained in a pure state, and weighing 290 grains, by treating it with muriatic acid, was converted into muriat of magnefia, which, evaporated to drynefs, amounted to 420 grains; exactly as it did in the foregoing process.

This

This portion of muriated magnefia, contained in the mother-water along with the muriated lime, and exceeding the latter in quantity, deserves particular notice. In both brines, in the graduated as well as the rough, the muriated magnefia amounted only to the 30th or 40th part of the muriated lime; in the mother-water, on the contrary, the quantity of the first exceeds the latter nearly by one fourth part. The cause of this seems to lie in the following circumstance:-It is customary, at Königsborn, to preserve the mother-water of 4, 5, or more boilings in the boiler. At any subsequent boiling, therefore, a stronger heat is required, to promote the crystallization of the falt; and when, in this case, a part of the bottom of the boiler becomes dry, a portion of the muriated lime is then decomposed, and its earthy basis becoming free, increases the calcareous earth in the schlot, or incrustation (pfannenstein) of the vessel: but the muriatic acid escapes in vapours, as may distinctly be perceived by the finell, and the votres and si sad )

### M.

# Incrustation of the boiler.

One Pound of it, pulverized and dried in a gentle heat, was boiled with 12 lb. of water. The filtered folution was next evaporated to drynes, and the falt obtained was treated in the method all along mentioned. When the undiffolved, grey-white, earthy residue was examined, it proved to be a mingled mass of sulphat of lime, of carbonated lime containing a little iron, and of a sandy siliceous earth.

The proportion of these constituent parts to each other was found to be as follows:

0	Y	190
-	L	L
0		100

i di bankanoo silsassa laminum 100z.	drach.	gr.
Moisture I	6	CATOR
Muriated lime	I	10
magnesia	OFFICE MA	10
Muriat of soda, with a scarcely per- ceivable trace of sulphated soda,  4	4	40
Carbonat of lime	2	30
Sandy filiceous earth	3	30
Sulphat of lime (selenite) 7	Talaw-	0

enody bus a sto od to no institution of o 16 Ounces.

tion of the muriated link a then decomposed, and his

# Dornenstein.

(That is, the earthy and faline incrustations formed on the brush-wood in the graduating houses .-- Transl.)

The Dornenstein of these salt-works consists of a darkbrown, compact, indurated, stony crust, similar to the incrustations at Carlsbad.

- 1.) Of this I boiled two ounces, reduced to powder, with a sufficient quantity of water. This, however, would disfolve but little; for, after evaporation, there remained only four grains of common falt, mixed with iron and selenite.
- 2.) The powder of the stone which remained after boiling was faturated with muriatic acid. The folution was attended with great effervescence, and, towards the end, was promoted by heat. When filtered, it left felenite behind.

- 3.) This muriatic folution, combined with caustic ammoniac, deposited a quantity of iron in a flocculent form; the weight of which, first ascertained when collected and ignited, was afterwards reduced to that of carbonated iron.
- 4.) The folution, now perfectly colourless, afforded carbonat of lime, by the addition of foda.

The proportion of the ingredients in these two ounces, or 960 grains of the mentioned Dornenstein, was:

Impure common falt	4 grains
Selenite	25
Carbonated oxyd of iron	92
calcareous earth .	828
Moisture	11
a Month sent spaceties ofer	
Community of their artificians	1060

What corrections, or improvements, might be made in the boiling of falt in the falt-works at Königsborn, in confequence of the analysis here communicated of the falt-brines, or springs of that place, and their products, I leave to the judgment of practical balurgists, or salt-makers.

But the advantage which the science may derive from the performance and collection of these and similar analyses, cannot be doubted: thereby, not only the sum of our observations hitherto collected, on the nature and constituent parts of salt-springs in general, will be rendered more complete and certain; but likewise the knowledge of the laws of elective attractions of bodies, in particular, will be

increased and corrected. An instance of this last is afforded in the prefent analysis, by the circumstance that, in these falt-brines, no glauber-salt is found, but only selenite; although the latter, fituated in the proportion in which it is contained in the mixture, should be decomposed according to the laws of affinities: at the same time that the foda of the common falt should combine with the fulphuric acid of the felenite, to form glauber-falt. But it must be here considered, that the agency of the attractive forces in bodies likewise depends on the various degrees of temperature: and this is really the case in this instance: for it is shewn, by experience, that the generation of sulphat of foda from the muriats of lime and foda, or, in other words, the generation of glauber-falt from felenite and common falt, can take place only at a cold, much below the point of freezing; but to fuch a low temperature the faltfprings are not exposed in their subterraneous reservoirs and canals. Whence it also happened, that when, with this view, I repeated the experiment with 16 ounces of the mass which incrusted the boiler (pfannenstein), and which, during the winter, had been exposed to the cold, and had, in part, fallen to pieces, the newly-generated glauber-falt immediately appeared. Its quantity, afcertained by means of muriated barytes, and calculated for the crystalline state, did, however, in general, amounted to no more than 36 grains.

Finally, the carbonic acid must also be added to the confituent ingredients in saline springs. This acid is extricated, in the usual form of air-bubbles, during the evaporation of the rough brine; and its disengagement causes the separation of the calcareous earth, now deprived of its solvent. The same escape of this volatile acid, and the same separation of the calcareous earth, likewise take place when the brines are graduated; in which case the carbonated calcareous earth, together with the oxyd of iron, fettles around the brush-wood, through which the brine passes, and forms the dornenstein. On this account, the graduated brines contain a much smaller proportion of calcareous earth; which, at the process of boiling, is fully deposited, and assists, in combination with the selenite, to form the compound with which the boiler is incrustated. (Pfannenstein).—What concerns the proportion of carbonic acid, contained in salt-springs, in a state of absorption, I did not, in particular, attempt to ascertain; as such enquiries cannot be made with any prospect of success, but with brines recently collected, and employed on the spot.

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honeimen . E. wice milere at Argintizes,

#### XXVII.

### CHEMICAL EXAMINATION

OF

## SPINELL.

I HE spinell seems to belong to those species of gems, which the antients understood by the name Hyacinth; as they do not ascribe to it the yellowish red colour, possessed by our modern hyacinth, but a light violet-red, and also a rose-red. Pliny \*, for example, fays:- " Multum ab amethysto distat hyacinthus, tamen e vicino descendens. Differentia bæc, quod ille emicans in amethysto fulgor violaceus, dilutus est in Hyacintho." Epiphanius enumerates five species of hyacinth, the third of which he calls NATIBOS+, stated by Salmasius to have been of a colour, qui inter roseum est, et dilutiorem. That the stone, now called hyacinth, has been mistaken for the hyacinth of the antients, was probably occasioned by the following passage of Pliny t:-" Hyacinthos Æthiopia mittit et chrysolythos aureo colore trans-Iucentes." But if in consequence of a sounder criticism the context be read thus :- Marcescens celerius nominis sui flore hyacinthus. Æthiopia mittit et chrysolithos, &c. it is obvious, that the aureus colour is referred to the chrysolite, which, as is well known, is the topaz of our days, and that it has nothing to do with the byacinthus of the preceding fentence. In this way, also, another apparent contradiction in Pliny is removed.

<sup>\*</sup> Lib. xxxvii. cap. 9.

<sup>†</sup> From the Arabic word, Natif, a red crayon colour. See Joan. de Laet de Gemmis et Lapidibus. Lugd. Batav. 1647.

<sup>1</sup> Loc. cit.

The reader likewise knows that the spinell has been hitherto ranked along with the ruby as its second species, so that the first species of that genus has included the true genuine ruby. But since Rome de l'Isle\* has directed the attention to the different form of crystallization of those two stones: observing that the crystals of the genuine ruby of Pegu are oblong, double, hexahedral pyramids, modern mineralogists have, upon this ground, ranked the ruby under the sapphire, as a red variety of it, and introduced the spinell as a distinct genus; which separation is also suggested by the difference of its hardness and specific gravity.

Besides these distinctions, the nature of the fracture also might serve to discriminate the genus. For the texture of the spinell is lamellar, in triple transverse laminas; the sapphire, on the contrary, exhibits in every direction only a slat conchoidal fracture.

Yet the furest way to decide on this point would be by chemical analysis; which, however, with respect to the ruby crystallized in hexhedral pyramids, or the red sapphire, can be at present but little hoped for, as it is so seldom met with in its rough state.

The original figure of spinell is the octahedron, or double four-fided pyramid. This crystalline figure is frequently found perfectly regular, but as often subject to many variations, which have been detailed and described with great diligence, and uncommon accuracy, by Abbé Estner ‡.

No less variable is the colour of the spinell; as it passes through almost all the shades of the red. This variation

<sup>\*</sup> Cristallographie, tom. i. page 213.

<sup>†</sup> Estner, Mineralogie, II. B. I. Abth. S. 96, 97.

<sup>1</sup> Ibidem, page 73. seq.

of colour has induced jewellers, or dealers in gems, to subdivide the genus of ruby, besides the genuine ruby, into almandin, spinell, ballass, and rubicell, as they usually do.

The red colour of this gem is not only very fixed, or permanent in the fire, but its pale variations are even still more heightened by means of a careful ignition. This property the inhabitants of Ceylon know how to employ to advantage, according to the testimony of Julius Scaliger;\* and, perhaps, on this dexterity of art depends the amazingly high and magnificent colour which we admire in fine, polished rubies, but do not perceive in the rough, uncut stones.

To the more uncommon variations of colour belong: 1. the spinell, quite colourless, and as limpid as water, of which Mr. Macie, in London, possesses a perfect octahedron in his collection of crystals; 2. the sapphire-blue spinell, in the collection of Francis Greville, Esq.; and 3. the green spinell, the property of J. Hawkins, Esq. likewise in London, &c. &c. This affords a new example, that, in determining the genera and species of gems, colour is to be considered as only a subordinate or secondary character.

The specific gravity of spinell I have found to be, in selected crystals, from 3,570 to 3,590.

Although feveral years ago I attempted and published a chemical analysis of the spinell, I have found some circumstances then not completely ascertained, which require ano-

<sup>\*</sup> Exercitationes, &c. No. exviii.

<sup>†</sup> Beob. u. Entdeck. a. d. Naturkunde, vol. iji. Berlin, 1789. page 336.

ther analytical process. The result of this has taught me, that on the first analysis of the spinell, I had thoroughly overlooked one of its constituent parts, which I did not suspect in it, and which is magnesian-earth. Among the various experiments, instituted for accurately determining the proportion of this newly discovered ingredient, I select that in particular, which led the nearest to sulfilling this object.

- a) One hundred grains of rough spinell from Ceylon, in picked crystals, previously pounded to a coarse powder in the steel-mortar, were triturated with water to an impalpable powder in the grinding-dish made of slint. After the powder of the stone, which was again dried, had been gently ignited, it shewed an increase of weight of nine grains, originating from the particles abraded from the substance of the grinding-vessel.
- b) I then strongly digested that powder with two ounces of muriatic acid. When the acid had been evaporated nearly to dryness, I diluted the mass with water, threw it upon the filter, and saturated the yellow muriatic solution with caustic ammoniac. A brown slocculent oxyd of iron fell down, which, collected and ignited, weighed 14 grain.
- c) The liquor separated from that precipitate was concentrated by evaporation, perfectly neutralized with muriatic acid, and, lastly, combined with dissolved oxalat of pot-ash (salt of wood-forrel). In consequence of this, oxalat of lime precipitated; which, when carefully collected, and heated to redness in the cavity of a compact piece of charcoal, with the assistance of the blow-pipe, assorded three fourths of a grain of lime, or pure calcareous earth. This last, dissolved in nitric acid, and treated with the sulphuric, produced selenite, or sulphated lime.

- d) Upon the powder of the stone, extracted by the muriatic acid, was poured ten times its quantity of alkaline lye, one half of which consisted of caustic alkali; which mixture being first evaporated to dryness, in a silver-vessel, upon a sand-heat, was afterwards ignited during the space of an hour. When the mass had been again softened with hot water, it lest on the filtering paper 54 grains of an isabellatellow residue when dried in the air.
- e) These 54 grains were a second time mixed, and inspissated with a tenfold quantity of the same caustic lixivium, and afterwards ignited. Upon which, the mass, softened again with water, deposited a residue of a fine pulverulent form, weighing 43 grains, when dried in the air.
- f) I then neutralized the yellow alkaline folution (d) and (e) by means of sulphuric acid, and by affusing more acid, made a clear solution of the precipitate, which then formed. Carbonat of pot-ash, added in a boiling state, threw down from it a precipitate of a very great bulk, which, after edulcoration, was again dissolved in sulphuric acid. This solution exhibited a slimy toughness; but it became perfectly stuid, when exposed to a raised temperature, and deposited a subtle white powder, which, after washing and desiccation in the air, weighed 95 grains. The sulphuric acid stuid, when separated from it, was set aside for a time.
- g) The above-mentioned 95 grains were then gently ignited with thrice their quantity of caustic pot-ash. When again liquested with water, and siltered, there remained only a slight residue, which, after washing, dissolved in sulphuric acid, with the exception of a few remaining particles.

- b) The portion taken up by the caustic pot-ash in the alkaline solution (g), was precipitated by means of sulphuric acid. But it dissolved again in the acid, when added to excess, and was afterwards precipitated by boiling with mild, or carbonated alkali. This precipitate, previously washed, was once more dissolved in sulphuric acid.
- i) The whole of the fulphuric folutions, obtained at (f, g, h), was evaporated to a smaller compass. The gelatinus consistence, into which it congealed, shewed that a separation of siliceous earth had taken place. It was therefore largely diluted with water, digested, and the silex collected upon the filter.
- k) This done, the fulphuric folution was put in a state to crystallize, by dropping into it a solution of acetite of pot-ash\*, and evaporating it slowly. It yielded at first regular and pure crystals of alum. But as the solution assumed a green colour towards the end, I combined it with Prussian alkali. A trisling precipitation ensued, of which the oxyd of iron could not be estimated more than at one source fourth of a grain. The solution, being now freed of its ferruginous ingredient, was next decomposed, in a boiling heat, by carbonated pot-ash; and the precipitate, when dissolved anew in sulphuric acid, was brought to a final crystallization; after which the sulphat of alumine then obtained was added to the foregoing.

<sup>\*</sup> Note. In order to add the vegetable alkali in the just proportion requisite to promote the crystallization of the sulphated alumine, I find it at present most convenient to employ that alkali in a state of saturation with acetic acid. By this manner I avoid the danger of decomposing a part of the alum just forming, by the quantity of alkali, that may easily happen to be added in excess.

- I) I now proceeded to the analysis of the 43 grains, that were left undissolved by the caustic alkaline lye (e). These readily dissolved in dilute sulphuric acid, leaving some filiceous earth behind. The solution, separated from this last, was then combined with a small portion of acetated pot-ash, and exposed to spontaneous crystallization by exhalation in the open air. At first there yet appeared some solitary crystals of alum; but afterwards it entirely shot into sulphat of magnesia (Epsom salt).
- m) To feparate the fulphated magnefia, thus obtained, from the admixed fulphat of alumine, it was ftrongly ignited in a porcelain-veffel during half an hour, and the faline mass afterwards fostened in water, and filtered. The aluminous, or argillaceous earth, separated by this management, was afterwards dissolved in sulphuric acid, and in the proper manner crystallized into concrete alum.
- n) The pure folution of the fulphated magnefia was precipitated in a boiling heat by means of vegetable alkali. The magnefian earth, thus obtained in a carbonated state, weighed 20½ grains, when washed and dried; but after strong ignition it weighed only 8¼ grains.
- o) All the washings (of which that at (f), on precipitating the sulphuric solution by carbonat of pot-ash, retained the yellow colour of the first solution) were, together, evaporated to a dry saline mass. When they had been re-dissolved in water, there still separated a little earth, which, along with the precipitate remaining at (g), was ignited with caustic pot-ash, and then by sulphuric acid resolved into aluminous and siliceous earths.
- p) The whole quantity of alum obtained at (k, l, m, and o) amounted to 665 grains. It was now diffolved in water,

and in a heat of ebullition decomposed by carbonated alkali prepared from tartar. The aluminous earth, thus obtained, when edulcorated with water, and dried in a moderate warmth, weighed 221 grains. But, after being purified by digestion with distilled vinegar, and subsequent saturation with ammoniac, and being again edulcorated, and at last subjected for half an hour to an intense red heat, it weighed no more than  $74\frac{1}{2}$  grains.

q) I then ignited, for half an hour, the whole of the filiceous earth collected from (i, l, o). Its weight was  $24\frac{1}{2}$  grains. Hence, fubtracting the nine grains which had been abraded from the flint-mortar (a), there remain  $15\frac{1}{2}$  grains belonging to the spinell.

From this analysis it follows, that the constituent parts of the *spinell* in the *bundred* are:

Alumine	•		p)				74,50	
Silex .			9)	-			15,50	
Magnesia								
Oxyd of i	ron		b) k)	1,25	}		1,50	
Lime .							0,75	
							100,50	-

The reason why, in this instance, there appears in the sum of the weights an excess of half a grain, rather than a loss, unavoidable in the usual course of such processes, is probably, that the ignition was not powerful enough to effect in those ingredients that high degree of dryness, which that stone possesses in its natural, undecomposed state.

With

## 324 XXVII. Chemical Examination, &c.

With regard to another analytical process made with spinell, and of which it would be superfluous to give a detailed description, as it only served to pave the way to the foregoing, I shall here merely relate the following phenomenon.—When the cohesion of the parts which constitute that stone had been loosened by alternate treatment with caustic pot-ash and muriatic acid, I introduced the earth, precipitated by ammoniac from the muriatic solution, into caustic alkaline lye. It dissolved therein for the most part, but not wholly. The undissolved remainder was upon this dissolved in muriatic acid; and when the siliceous earth, which then appeared, had been removed, the sluid was again evaporated to a smaller volume.

After some days standing, there appeared in it a quantity of small crystalline groups, consisting of clear, and seemingly quadrilateral, somewhat slattened, little columns; the greater number of which were joined by two and two, in the form of an X, but the others in groups of three, and more, in a stellated manner.

These crystals readily dissolved in water. The precipitate, thrown down by caustic ammoniac, was of a light-brown, on account of some portion of iron, which still adhered. It was then dissolved in sulphuric acid, and this new combination was again set to crystallize in the slowest manner. At first there appeared crystals of alum; but the remainder of the solution gradually shot into sour-sided columnar crystals of sulphated magnesia.

It is this crystallization of magnesia, mixed with alumine in muriatic acid, which I think worth remarking.

#### XXVIII.

### CHEMICAL EXAMINATION

OF THE

# EMERALD from Peru.

THE emerald is one of the best known gems, and it has been reckoned even in remote antiquity among the most esteemed precious stones, on account of its rich green colour, so grateful to the eye. Pliny enumerates twelve species of it, and considers the Scythian, Bastrian, and Egyptian, as the most eminent. However, it can hardly be doubted, but that, in those days, various essentially different species of stones of a green colour were comprised under that name; as is frequently done in our days. The acquaintance of Mineralogists with the genuine emeralds, which were furnished by the parts of the globe the longest known, seems at present to be almost entirely obliterated by our familiarity with those which are found, though sparingly, in the provinces of South-America, and principally in Peru.

a) For the following analysis I made use of the crude, crystallized emerald, of a high grass-green colour, from Peru\*. I pounded it in a steel-mortar to a coarse powder, and triturated one hundred grains of that powder very finely

with

<sup>\*</sup> For the specimen of emerald facrificed to this analytical process, I am indebted to the liberal kindness of Prince Dimitri Gallitzin, whose zeal for the study of Mineralogy is most honourably known.

with water, in the flint grinding-dish. After gentle ignition, I found its weight increased by about 1½ grain.

- b) The powder of the stone was covered, and several times digested in a strong heat, with muriatic acid; which immediately acquired a yellow colour. After having again siltered off the acid, I saturated it to excess with caustic ammoniac; and by this management there separated light, brown slocculi, which, collected and ignited, weighed half a grain, and were oxyd of iron. The sluid was next evaporated to a part, and treated with carbonated ammoniac. But it continued clear, and thus shewed, that it contained no calcareous earth.
- c) Fourteen drachms of caustic alkaline lye, made of seven drachms of the falt dissolved in as many of water, were then affused upon the powder of the stone extracted by the muriatic acid (b); and after the mass had been previously evaporated to dryness in a silver-crucible, I subjected it to a red-heat for half an hour. However, it would not suse, but appeared, after ignition, in an intumesced, friable state, and of a white colour.
- d) On being foftened with water, and treated with abundance of muriatic acid, it afforded a very limpid folution, from which the earthy ingredient was precipitated by carbonated pot-ash, with the affistance of heat. The precipitate had a granular form; and when finely ground, the greatest part seemed to dissolve in muriatic acid, which was poured upon it. But as soon as the mixture had been exposed to a digesting heat, it coagulated to a transparent thick jelly. When diluted, and digested with more water, it deposited siliceous earth to the amount of 67 grains, after washing and ignition. This earth was then mixed with four parts of carbonated pot-ash, and ignited to an incipient suspense.

fusion, in a crucible made of filver. Upon the mass, redisfolved in water, which afforded a somewhat turbid solution, I poured muriatic acid to an excess of saturation, and digested them together. The filiceous earth, which I thus recovered, was now perfectly pure, and weighed 63½ grains, after having sustained a red heat.

- e) The muriatic folution, feparated from this filex, together with the preceding (b), was faturated with an overproportion of caustic ammoniac. The paste-like precipitate, thence arising, was immediately removed, and the filtered liquor combined with carbonat of ammoniac; which, however, would throw down nothing more. Sulphuric acid quickly dissolved this precipitate. By the addition of a little acetite of pot-ash, the whole of the solution yielded crystallized alum, with the exception of some silex, which still separated, and weighed  $4\frac{\pi}{2}$  grains, after ignition.
- f) From the above fulphat of alumine (e) being re-diffolved in water, I precipitated the argil by carbonated potath. When the earth had been again deficcated, I poured upon it distilled vinegar; put the whole in a warm place; saturated the acetic acid with caustic ammoniac; and, lastly, filtered the mixture. What remained of the sluid suffered no alteration, either by carbonat of ammoniac, or by carbonat of soda. The aluminous earth, now obtained in a state of purity, was first dried, then ignited, and found to weigh  $31\frac{1}{4}$  grains.

Therefore, the constituent parts of one hundred grains of Peruvian emerald, here decomposed, yielded:

328 XXVIII.	Analysis	of t	he, &	·C.	
Silex	d) .		grains		
Subtract	a) .	67 <sup>3</sup> / <sub>4</sub> 1 <sup>1</sup> / <sub>2</sub>			
Alumine, or argil Oxyd of iron .		. 8.			66,25 31,25 0,50
opinari, kulomoridi. Opinarion, municipali				-	98

[ 329 ]

#### XXIX.

### CHEMICAL EXAMINATION

OF THE

### BOHEMIAN GARNET.

THE denomination garnet served to the elder Mineralogists as a generic, or collective-name, in which they included almost all roundish crystalline forms, encompassed by defined lateral facets, or all the species of stones, of, as they were called, a polyhedral crystallization. At present, however, the generic name, garnet, has been confined within narrower limits; for the white garnet, as well as the black, have been justly removed from it, and arranged as distinct genera: the first under the name Leucite; the second under that of Melanite.

It may also be foreseen, that several other fossils now classed as species, or as varieties of the garnet, besides those last mentioned, will in time receive another place in the systematic arrangement of minerals: in consequence of more accurate observations concerning the deviation, not only with regard to their external appearance, but likewise with regard to their chemical constituent parts, by which they are distinguished from the true and strictly determined principal genera, to which last the Bohemian garnet principally belongs.

The Bohemian garnet, (whose occurrence, method of procuring it from the mines, and external characters, are too well known to require any farther illustration in this place),

place), when weighed in water, lost 269 parts of 1000 of its absolute weight; its specific gravity therefore is = 3,718.

It fuses by itself alone in a proportionate intensity of heat\*. The iron which it contains is reduced to the reguline state, when exposed to the action of fire in the charcoal-crucible. From 100 grains of Bohemian garnet I obtained a button of iron, of 10½ grains weight.

In order to find out its conflituent parts, I subjected it to the following experiments.

- a) I ground two bundred grains of Bohemian garnet, previously pounded in the steel-mortar, with water, to a fubtle powder, in the flint triturating dish. When dried, and gently ignited, the powder of the stone was found increafed in weight by feven grains. I inspissated it with a lixivium, made of 600 grains of caustic pot-ash, in a filvercrucible, and ignited it afterwards for half an hour. The ignited mass was then softened with water, lixiviated, and filtered. The filtered lixivium was of a light grafs-green, but foon loft that colour, and became light-brown. By exposure to a warm temperature, it deposited, after 24 hours, an oxyd of manganese, which, collected in a porcelain-cup, amounted to about half a grain. On fufing it upon charcoal, with a neutral phosphat, and covering it with nitrat of pot-ash, the salt exhibited, after detonation, a dark violet-red colour, mingled with green spots.
- b) The alkaline lye was then super-saturated with muriatic acid, and evaporated nearly to dryness. After re-dissolving the saline mass in water, filiceous earth was deposited, which weighed II grains, after edulcoration and ignition. When

this had been feparated, fome aluminous earth was thrown down by carbonated foda from the muriated folution. As the remaining liquor still appeared of a yellow tinge, it was again evaporated to a dry salt. But this likewise had a citron-yellow colour, and again afforded a yellow solution with water; from which, however, nothing could be farther separated, by any means whatever.

- c) The lixiviated powder of the garnet had the colour of a light-brown iron ochre. To this I added the small portion of alumine (b), and treated it with muriatic acid, with which it immediately formed a golden-yellow solution. When this last had been evaporated, in a sand-heat, to a gelatinous consistence; it was again largely diluted with water, once more digested and siltered. The siliceous earth, being well lixiviated, and heated to redness, weighed 76 grains.
- d) Caustic ammoniac threw down from the muriatic solution a copious brown precipitate; which, after being collected on the siltering paper, was washed, and dried in a moderate warmth.
- e) The colourless fluid, remaining after the precipitation with caustic ammoniac (d), was evaporated in part, and combined with carbonated soda. By this management, carbonat of lime fell down, which, after drying, weighed  $12\frac{3}{4}$  grains, equal to seven grains of ignited calcareous earth, or burnt lime.
- f) I then divided the brown precipitate, obtained by means of ammoniac (d), into two equal parts.

One half of it I exposed to strong ignition in a covered crucible, and found, after this, its weight to amount to 55 grains.

g) The other half I diffolved again in muriatic acid, diluted the folution with a fufficient quantity of water, and precipitated its portion of iron by Prussian alkali. The separation of the dark-blue precipitate being accomplished, I precipitated the solution, now freed from iron, by means of carbonated soda, and in a boiling heat. The quantity of the white, loose earth thus obtained amounted, after washing, drying, and ignition, to 38½ grains.

From this it was manifest, that the proportion of exyded iron, separated by prussiated pot-ash, amounted to  $16\frac{1}{2}$  grains.

- b) The above  $38\frac{\pi}{2}$  grains of ignited earth (g), were then diffolved in fulphuric acid, and made to crystallize, after the addition of a proper quantity of acetated pot-ash. The first shootings yielded regular crystals of alum. But the last shewed, by the oblong, four-sided columnar figure of its crystals, that it was sulphat of magnesia.
- i) But as the sulphat of magnesia could not be separated from the alumine with sufficient accuracy, I subjected the whole of the saline mass to strong ignition for an hour; after which I liquested the ignited mass with water, and combined the mixture, at a raised temperature, with powder of calcined oyster-shells, added in small portions, until the solution no longer reddened paper tinged with litmus. The siltered solution tasted now like pure sulphat of magnesia; and, when set to crystallize, I obtained from it 69 grains of this neutral salt. However, on being re-dissolved in water, it still deposited two grains of sulphated lime: hence its true quantity amounted to 67 grains.
- A) To recover from it the earth in a separate state, I precipitated the solution, in a boiling heat, by carbonat of soda.

foda. The magnesian earth, washed and dried, weighed 23½ grains; but when heated to incandescence in a covered crucible, and kept in that state during half an hour, it weighed but 10 grains.

By fubtracting these 10 grains of magnesia from the above  $38\frac{1}{2}$  grains (g), there remain  $28\frac{1}{2}$  grains for the aluminous earth.

One hundred grains of Bohemian garnet confift, therefore, of:

Silex	b) 5½ c) 38		
and deducting .	43½ (4) 3½	**	
	40	 	40,
Alumine	k)	 	28,50
Oxyd of iron	g)	 	16,50
Magnefia	k).	 	10,
Lime	e)	 	3,50
Oxyd of manganese	a)	 	0,25
	16	1	
			08.75

#### XXX.

### CHEMICAL EXAMINATION

OF THE

## ORIENTAL GARNET.

THE Oriental, or Sirianic Garnet\*, is distinguished from the Bohemian, both by its violet-red colour, and by its specific gravity; which is = 4,085. This higher weight of it depends on the greater proportion of iron which it contains, and which is so considerable, that, by mere susting in the charcoal-crucible, I obtained from 100 grains of the oriental garnet a fine button of iron, of 23 grains. It likewise, when sused alone, in a crucible made of clay, runs into an enamel glass of a blacker colour than that of the Bohemian garnet †.

a) Two hundred grains of oriental garnet, previously bruised into small pieces, in the steel mortar, acquired eight grains additional weight from the substance of the slint-grinding dish, in which they were finely levigated with water. The powdered garnet was put in a caustic lye, in which the alkaline ingredient constituted thrice the weight of the powder; and, with this, it was inspissated to a dry mass, in a crucible made of silver. It was next subjected to red-heat during half an hour; and when the ignited mass

<sup>\*</sup> Rather Sirianic, than Sirian garnet: from Sirian, a town in Regu, now destroyed.

<sup>+</sup> See Effay I. No. 40.

had again been fostened with boiling water, the powder of the stone, separated from the decanted liquor, was lixiviated and dried.

- b) The alkaline lixivium was of a bright grafs-green. But it was foon deprived of that colour by exposure to a warm temperature, at the same time that it deposited an exyd of manganese, impregnated with iron, in a brown slocculent form, and weighing about ½ grain when ignited.
- c) The alkaline lye was now devoid of all colour. It was faturated with muriatic acid, and evaporated in part. A light flocculent earth then separated, but part of it dissolved again upon super-saturation with muriatic acid. The infoluble residue consisted of siliceous earth of 9½ grains after ignition. That part of the earth, which had been re-dissolved by the excess of acid, was then separated afresh by carbonat of pot-ash. After ignition, this earth weighed 4½ grains; and, upon being tried by sulphuric acid, it proved to be pure alumine, or aluminous earth.
- d) The edulcorated powder of the stone (a), which had a cinnamon colour, and a very incoherent form, was moistened with water, and treated with muriatic acid, in which it rapidly dissolved, without leaving any residue. The liquor was limpid, and of a golden-yellow. But, on being subjected to evaporation, on a sand-bath, it coagulated into a semi-translucid, gelatinous substance; which had a deep golden-yellow colour, and was again digested for a while along with water that was poured upon it, and with repeated stirring. When, after this, it had been brought upon the filter, it lest siliceous earth in a swelled state; which, being thoroughly edulcorated by a frequent affusion of hot water, and desiccated, weighed 104 grains, but only 70 grains when heated to redness.

- e) To the muriatic folution, diluted with the washings of the filex (d), I added caustic ammoniac in excess. It gave a copious brown-red, much intumesced precipitate, the quantity of which, after washing and drying, amounted to 190 grains.
- f) The colourless fluid remaining from this last process was first combined with as much muriatic acid as was requisite to saturate the predominant portion of ammoniac, and then with carbonated soda. But as this produced no turbidness, I evaporated the whole of the liquor to a dry saline mass, which being re-dissolved in a little water, I tried it once more with carbonat of soda. The mixture still continuing clear, shewed, that it contained no other constituent part.
- g) Those 190 grains of the brown-red precipitate, obtained at (c), were divided into two parts.

One half was ignited, and then found to weigh 61 grains. I poured upon it fulphuric acid, evaporated it to dryness; and after having strongly ignited the saline mass for two hours, in a melting pot, I extracted it with water, and combined the filtered, clear sluid with carbonated soda, in a heat of ebullition. There separated, however, some scarcely perceptible slocculi of aluminous earth only, without any trace either of lime, or of magnesia.

b) The other half of the precipitate was dissolved in muriatic acid; and, after sufficient dilution with water, combined with Prussian alkali, added successively, till all the ferruginous parts were separated. The blue precipitate of iron weighed 185 grains, when washed and desiccated. After being strongly ignited in a covered crucible, there remained 72 grains of iron attractible by the magnet. One

part

part of it was affayed for manganese by fusion with a phosphated alkali; but it gave no indication of this metal.

- i) The folution being now freed from the iron (b), it was decomposed in a boiling heat, by carbonated soda, and the precipitated earth lixiviated, and heated to redness. It weighed 25 grains; whereby, subtracting it from the 6r grains, obtained from the first half of the precipitate (e,g), the portion of iron, contained in 100 grains of this garnet, is found to be 36 grains.
- k) When the above 25 grains of ignited earth (i) had been diffolved in sulphuric acid, and, after the addition of acetated pot-ash in due proportion, was set to crystallize, they afforded to the end crystals of pure sulphat of alumine.

It refults from this decomposition, that the constituent parts of the oriental garnet are in the hundred:

Oxyd of iron :		i)			*	-	36
Silex		(2)	434				
*A		d)	35			1	
Subtract		a)	39 <sup>3</sup> / <sub>4</sub>				
Alexanian .				•	*		35,75
Alumine			25				
		-			4 11		47.3
		1.	274			0	27,25
Oxyd of manganese		6)					0,25
		2	,				99,25 XXXI.
		4	1				2121210

#### XXXI.

### CHEMICAL EXAMINATION

OF

### VESUVIAN.

#### FIRST SECTION.

Vesuvian, from the Mountain Vesuvius.

AMONG the different forts of stones, which the Mountain Vesuvius brings up from the bowels of the earth, in their native unaltered state, that crystalline fossil may be reckoned, which the inhabitants of Naples call the Vesuvian sem.—Mineralogists had variously classed it with short, chrysolite, hyacinth, topaz, &c. and by the adjective, vesuvian, or volcanic, distinguished it as a variety of the above mentioned gems; till Werner established it as a distinct genus of stones, and gave it the name, Vesuvian; 28, till then, it was sound on Mount Vesuvius only.

An oryctognostic description of that fossil is already met with in various elementary treatises on mineralogy. That given by Estner\* is particularly accurate and complete, for which reason I direct the reader chiefly to it.

<sup>\*</sup> Estner, Versuch einer Mineralogie für Anfänger und Liebhaber. II. Band. Seite 177 seq.

# Examination in the dry way.

a) A finall piece of vefuvian, if ignited upon charcoal before the blow-pipe, gradually rounds itself into a darkbrown, shining, opake globe, transparent only in splinters.

Borax (borat of foda) dissolves it by degrees, to a clear light brown, and fomewhat bliftered, or air-bubbled glafsbutton.

It is not, however, completely dissolved by means of a neutral phosphat, for this only envelopes the particles of the fosfil, in the form of an amorphous frothy scoria.

The habitude of vefuvian is more remarkable, when acted upon by a greater intenfity of heat in the charcoalcrucible, which I have already communicated in the first of these essays, page 32, n. 103. The regular group of crystallization, there described, of the tender crust that surfounds the fused vesuvian, is a phenomenon according to my experience, the only one of its kind; and repeated experiments have convinced me that it is constantly the same.

#### B.

# Examination in the humid way.

To decompose the vesuvian in the humid way, I picked out the best crystallized pieces of that variety which had a brown colour, inclining to olive-green. These were coarsely powdered, and, by elutriation, freed from the greenith-white and delicate lamellas of chlorite and mica, which still adherad. hered. Placed upon the hydrostatic balance, in this purified state, its specific gravity was 3,420.

- a) Hundred grains of it were reduced to an impalpable powder, by levigation with water in the flint-triturating dish. After gentle ignition, its weight was found to have encreased half a grain. Caustic alkaline lye, containing 300 grains of the salt, was then affused upon it, in a silver pot; and the mixture being first desiccated in a sand-heat, was next subjected to strong ignition, during half an hour Shortly before ignition the mass acquired a vivid, light, grassgreen colour, but which was afterwards mostly changed into a dirty olive-green.
- b) The ignited mass, while yet warm, was softened with water, and thrown upon the filter. The filtered lixivium appeared of a pale greenish hue, but soon grew feebly brown-red. During gentle digestion, there subsided loose, dark-brown, slocculent particles, leaving the lye colourless. As it could be foreseen that they would not well separate from the filtering paper, I collected them in a small porcelain-vessel, and dried them, after edulcoration. By this treatment I obtained a dirty-brown powder, consisting of a grain of oxyd of manganese. When conveyed into sused phosphoric salt, it dissolved in it clearly. The glass-globule, thus formed, became by turns colourless and amethyst-red, accordingly as I directed on it the inner or the outer point of the slame.
- c) Upon the pale-brown, loofe vesuvian powder, ignited with caustic alkali (a), edulcorated and dried, I poured muriatic acid; which dissolved it, with a little effervescence, and left some filiceous earth behind.

- d) The yellowish solution, together with the washings when reduced in bulk by evaporation, formed a clear coagulum of a full golden-yellow. By diluting it again with much water, and digesting it for some time under repeated agitation, the filiceous earth was rendered disposed to separation; I then collected it on the filter, and having added the foregoing portion (c), I ignited them both. They weighed together 36 grains.
- e) Having thus freed the muriatic folution from all its filex, I added to it caustic ammoniac in a greater quantity than its saturation required, and immediately gathered on the filter the swelled precipitate thereby produced; which, upon being perfectly lixiviated, was conveyed into a caustic alkaline lye. It soon dissolved in it upon the fire, leaving, however, a loose, brown-red, muddy substance behind.
- f) Both alkaline lixivia, that of (e), and that of (b), were then mixed, and over-faturated with fulphuric acid, till the earth, first thrown down by the acid, was again dissolved. Upon this I precipitated the earth by carbonated pot-ash, edulcorated and re-dissolved it in fresh sulphuric acid, adding then a small portion of acetated pot-ash, and prepared the solution for crystallization. It yielded crystals of alum to the end, which I re-dissolved in water, and precipitated its earthy portion by pot-ash. The aluminous earth here obtained, when washed and ignited, weighed 19½ grains.
- g) That fluid, which remained on the precipitation, effected by caustic ammoniac (c), was then concentrated by evaporation, and mixed with carbonated ammoniac. Sixty grains of crude calcareous earth, or carbonat of lime, fell down, which, in the ignited or pure state, are equal to 33 grains.

b) The brown residue, remaining from the solution of the argillaceous precipitate, in the caustic lye (e), was found to weigh 13 grains upon exsiccation. Muriatic acid was poured upon one half of it, and completely dissolved it. Prussiat of pot-ash, which was next added, produced a quantity of Prussian blue, of a pure deep colour. Carbonated ammoniac poured into the liquor, separated from this last, still precipitated some aluminous earth, weighing I grain after ignition. The second half of that brown residue weighed sive grains after exposure to red-heat. From this it followed, that for the above-mentioned 13 grains of residue, we must reckon 7½ grains of ignited oxyd of iron, and 2½ of ignited aluminous earth. Some experiments made with that oxyded iron, to detect whether it contained manganese, evinced it to be absolutely free from this ingredient.

Hundred parts of vefuvian from Mount Vejuvius, therefore, contain:

### SECOND SECTION.

98,50

## Vesuvian from Siberia.

THE fossil, which I here introduce by that name, belongs to the discoveries, as yet little known, made in Siberia, a country,

country so extensive and abundant in remarkable mineral substances. It was discovered in the year 1790, by Laxmann, at the mouth of the river Achtaragda, where it falls into the stream Wilui. The first notice of it has been given by Pallas\*, under the name Crystals of Hyacinth, together with a delineation of some of these crystals, added to their description.

Their external colour is a dark olive-green, which, in the interior furface, passes into the brown of colophony (the residue of distilled turpentine). Their form is a rectangular four-sided column, with truncated edges; yet the facets of the truncations are sometimes so large, that the crystals might almost be called eight-sided prisms.

In the entire crystals both ends of the column are sharpened off to a quadrilateral pyramid. The points, however, are more or less, and in part, very much truncated.

As to the fize of these crystals, the breadth of the column, in the specimens which I possess, is from  $\frac{1}{2}$  to  $\frac{3}{4}$  of an inch; and the length, not measuring the pointed termination, from  $\frac{1}{2}$  to a whole inch.

The external lustre is but moderate; the internal is brighter, and partaking of the greafy gloss. The fracture is of the imperfect, small conchoidal kind, and distinctly exhibits, especially the longitudinal one, a foliated texture.

This fossil is opake in its entire crystals; but its fragments are transparent, and even semi-pellucid.

The

<sup>\*</sup> Pallas Neue Nordische Beyträge, vol. v. Petersburg and Leipzig, 1793, page 282.

The gangue confifts of a pale, greenish-grey, dull stone, which seems to be of the serpentine kind; and in which those crystals are singly imbedded.

Of one of those crystals, whose absolute weight was 253 grains, I found the specific gravity to be 3,365; that of another, weighing 188 grains, was 3,390.

On some of those crystals there are observed small, opake, insulated grains, formed like garnets, and of a greenish or yellowish-white colour. Some of these adhere but loosely; but others are more deeply concreted with the body of the crystals; yet, notwithstanding this, they may be easily separated, though they leave a cavity on the surface fitting their figure and size. When sufed before the below-pipe, they run into a dark-brown smooth globule.

It has already been remarked by Pallas\*, that this fosfil highly resembles the vesuvian of Italy; and this agreement has been more determined by Estner+, on the ground of the external characters of both. This oryctognostic conjecture has been confirmed by the following chemical examination,

#### A.

# Examination in the dry way.

a) The vestivian from Siberia, either when ignited by itself, upon charcoal with the affistance of the blow-pipe, or when sused, under the same circumstances, with glass of borax, or with a neutral phosphat, shews, in every respect, the same

<sup>\*</sup> Loc. cit.

<sup>†</sup> Versuch einer Mineralogie, vol. II. page 184.

relations as that from Mount Vesuvius, treated of in the foregoing section.

b) One piece of it inclosed in the charcoal-crucible, and committed to the fire of the porcelain-furnace, fused to an ash-grey, dense, vitreous globe of a gross-conchoidal fracture, and pellucid in thin fragments, the external surface of which was beset with numerous grains of iron.

But I have not perceived, on this globe, any distinct trace of that crystalline crust, by which the Italic vesuvian, if fused in the same manner, is rendered so peculiarly remarkable.

#### B.

## Examination in the humid way.

- a) One hundred grains of the above fossil, taken from a perfectly pure crystal, were finely pulverized with water in the slint-grinding dish. Their weight increased half a grain. When inspissated with a solution of 300 grains of caustic pot-ash, and afterwards ignited for half an hour, a pale-greenish mass was produced, inclining here and there to the brownish, which, lixiviated with water, left a light-grey powder upon the siltering paper.
- b) The lye, recently filtered, had a pale, dirty-brownish colour, but it soon became colourless; and, at the same time, that some few brownish slocculi were deposited, which, undoubtedly, were oxyded manganese, but could not well be collected and examined, from their very minute quantity. When that lixivium had been neutralized with muriatic acid, aluminous earth fell down, which a slight excess of that acid has again entirely dissolved.
- c) The undiffolved refidue of the alkaline folution (a) was digested with muriatic acid. There remained some filiceous

filiceous earth, which I feparated. Caustic ammoniac was then added in excess to the yellow solution, which had been mixed with the preceding (b), and it threw down a very intumesced light-brown precipitate, the separation of which was accomplished in an instant.

- d) That precipitate, duly washed, and while yet moist, I digested with caustic alkaline lye. It was but slowly dissolved in this menstruum, and left a residue, the great volume and slimy appearance of which indicated, that it could not consist merely of oxyded iron, but was still mixed with silex. For this reason, I digested it with dilute muriatic acid, and evaporated it to a thickish mass; which, being again diluted with water, deposited the siliceous earth contained in it.
- e) Caustic ammoniac, added to this solution, now free from all silex, again produced a brown paste-like precipitate, that readily dissolved in caustic lye, leaving a brown slocculent oxyd of iron behind, weighing  $5\frac{1}{2}$  grains when ignited.
- f) To the alkaline lixivia of (d and e) an over-proportion of muriatic acid was added. They were then mixed with the muriatic folution (b), and together precipitated by carbonated pot-ash, with the assistance of heat. The earth, thrown down by this treatment, was re-dissolved in sulphuric acid. There still appeared some siliceous earth, after the separation of which, the solution, by proper management, crystallized into pure alum. This being again dissolved in water, I precipitated its aluminous earth, purished it afterwards by means of acetic acid and ammoniac, and when dried, I heated it to redness. It then weighed 164 grains.
- g) What remained of the fluid, after the precipitation by caustic ammoniac (c), was evaporated to a part, and upon

this combined with carbonat of ammoniac. Thus it afforded 62 grains of carbonat of lime, which are equal to 34 grains of pure calcareous earth.

b) The feveral portions of filiceous earth of (c, d, and f), when ignited and weighed together, amounted to  $42\frac{x}{2}$  grains.

It then refults from this analysis, that the constituent parts of the vesuvian from Siberia are precisely the same as those of the Italian. Only some variation takes place in their proportions, which, however, is no argument against placing them in the mineralogical system as two species, or even merely as varieties of one species. For an hundred parts of the Siberian sofill yielded:

Silex			b)			42 <u>I</u>	gr	ains	or or or
minus			a)			1 2			
					-	in usz			
						4.2			42
Lime			g)				eter		34
Alumine .			f)						16,25
Oxyd of iron			e)						5,50
Oxyd of many	gan	ese	b) :	a tra	ice	only			

the social days to design white the 97,75

#### XXXII.

#### CHEMICAL EXAMINATION

OF

#### LEUCITE.

### FIRST SECTION.

THOUGH the fossil at present known by the name Leucite or Leucolite, according to others, often occurs in Italy, (where it constitutes one of the ingredients not only in the lavas, the crude as well as those that have been converted by volvanic fires into tusas and slag-sand, or volcanic ashes, but also of other mingled masses of rocks) yet there are but very scarce and uncertain indications of its existence in other regions\*. The leucite is remarkable by its very determinate specific figure, which consists of low, double octahedral pyramids, slatly sharpened off to sour terminating surfaces; so that it forms a roundish crystal, inclosed in 24 trapeziums.

Still less does that leucite seem to be known, which occurs in the rocks of Vesuvius, either in masses or in an indefinite form, variously mingled with black mica, black acicular shorl, hornblende, crystals of vesuvian, &c. and which hitherto has been mostly considered as glassy selfpar, or granular quarz.

<sup>\*</sup> Of the fossils foreign to Italy, and taken for leucite, that in particular will most probably be confirmed as such on chemical examination, which Dr. Reuss, so deserving in the mineralogical history of his country, has found in Bohemia, and described. See his Mineralogische Geographie von Böhmen. Dresden, 1797, vol. 11. page 311—404.

# XXXII. Chemical Examination of Leucite 349

The former denomination of this fossil, white garnet, Vesuvian garnet, garnet-shaped short, is no longer to be retained, since the improvements made in Orystology. On the other hand, Werner has assigned to it a peculiar place in the mineralogical system, as a distinct species.

For the following analyses I have selected only such crystals of leucite ejected by Vesuvius, as, by their external appearance and internal lustre, together with the yet unchanged state of their stony matrix, (which is a black-grey corneous mass of basalt), have convinced me, that they had suffered no alteration either by volcanic fire, or by any subsequent decay. Most of them were of the fize of a nutmeg and upwards. Before they were employed, they were freed as much as possible from the stony matrix adhering to their outside, and likewise from the particles of hornblende usually contained in their middle. In this purished state their specific gravity was 2,455.

#### A.

# Examination in the dry way.

- a) The leucite is completely infufible, if ignited alone upon charcoal. It then undergoes no manner of fenfible alteration, and its fplinters lose nothing of their lustre.
- b) If a small fragment of it be put into fused borax, it is for a long time moved about in it before it dissolves, which it does by degrees. The glass-globule, arising from thence, is clear and light-brown
- c) By fusion with a neutral phosphat, the solution is still slower, and a colourless risty glass-pearl is produced.

d) One

- d) One hundred grains of coarfely pounded leucite were exposed for an hour to a strong red-heat, in a small porcelainpot. The loss of weight caused by this was only one-eighth of a grain.
- e) Even the violent heat of the porcelain-furnace produced in the leucite only an inconfiderable change \*.

B.

# Examination in the humid way.

(1.)

- a) Hundred grains of leucite, reduced to an impalpable powder, were feveral times digested in muriatic acid, which dissolved a considerable part. There remained a filiceous residue, of 54 grains, after ignition.
- b) This filiceous earth was then ignited with twice its weight of caustic alkali, softened again with water, covered with muriatic acid, added to excess of saturation, and, after sufficient digestion with this last, collected on the filter, and heated to reduces. It was found to have suffained, by this, a trisling decrease of weight.
- c) On adding pruffiat of pot-ash to the muriatic solution, a precipitate ensued of so small a quantity, as hardly to indicate one-eighth of a grain of oxyded iron. As, besides, this slight portion of iron, probably, does not originate from the leucite itself, but from some particles of hornblende not perfectly separable, I shall not consider it among the constituent parts of that mineral.

- a) Upon this I decomposed the solution by caustic ammoniac; and, after having separated the precipitate thus obtained, I tried the remaining liquor with carbonated soda, but no farther change was effected by it.
- c) The precipitate produced by means of pure ammoniac (d) was first dried. It was next purified by digesting it with distilled vinegar, and afterwards neutralizing this acid by ammoniac. It weighed 24½ grains, when edulcorated and ignited. Dilute sulphuric acid completely dissolved it to a limpid liquor, and when properly treated, the solution yielded only alum.
- f) To obtain the earth, which possibly might have remained latent in the several washings, I evaporated these to dryness. After having re-dissolved the saline mass in water, I collected the portion of earth which still appeared. However, it amounted only to half a grain, and was siliceous earth.

Therefore I obtained:

This confiderable loss, in the sum of the weights of the separated constituent parts of the leucite, during this analysis.

lysis, has induced me to repeat the experiment with some variation in the process.

- a) One hundred grains of leucite were finely ground, and ignited during half an hour, with twice their weight of caustic pot-ash. To the mass, again softened with water, muriatic acid was added, to just the quantity necessary for saturation. When the mixture had been siltered, I edul-corated and dried the remaining undissolved powder of the stone.
- b) The leucite, thus prepared for decomposition, was then extracted, in a boiling heat, by means of muriatic acid. There separated some filiceous earth, which weighed 54½ grains after having sustained a red-heat.
- ration, and tried by oxalat of pot-ash; but no precipitation nor turbidness ensued. After this I recovered the aluminous earth in its pure and separate state, by the same means as employed in the preceding experiment. Its weight, after ignition, likewise corresponded, to within a trisle, with that of the first analysis. It also shewed, upon farther trial, by re-agents, that, except an unimportant trace of oxyded iron, it was not in the least mixed with any other earth, of whatever kind.
- d) In the fame manner, nothing more, of an earthy nature, could be obtained from the edulcorating waters by evaporation.

### SECOND SECTION.

This agreement of the results of these two analytical refearches increased my uncertainty where to look for the cause cause of that loss of weight. At the same time it gave additional strength to the conjecture, long since entertained by me, that in the mixture of fossils, besides the constituent parts, found by analysis, there might be present other component principles, which have hitherto escaped discovery. That chemical decompositions of bodies, even when instituted with all possible care, are attended by some loss, is founded on the nature of the subject itself. However, the above loss was too great to be included in that which is absolutely unavoidable. It is, indeed, the shortest way to get over the difficulty, if the loss in the sum of the weight of the ingredients, although of some importance, is accounted for simply by the air and particles of water expelled. But such an explanation would by no means be capable of satisfying me in the present case.

I was fully convinced, that, in those processes, at least no earthy, or any other component part, soluble in water, had been lost. It was likewise evident, from the experiments related in the beginning of this essay, that neither water nor carbonic acid was to be sought for in leucite. For these reasons, I proceeded to other experiments, which tended to try that sossil, for the phosphoric, fluoric, and boracic acids; but of none of these I could discover any sign.

On the contrary, I was surprised in an unexpected manner, by discovering in it another constituent part, consisting of a substance, the existence of which, certainly, no one person would have conjectured within the limits of the mineral kingdom, and, least of all, in the natural mixture of a solid fossil, which, in a mineralogical sense, is simple or unmixed.

This conflituent part of leucite, which now appears in the character of an oryctognostic or mineral substance, is no other than pot-ash, which, hitherto, has been thought ex-

clusively

clustively to belong to the vegetable kingdom, and has, on this account, been called VEGETABLE ALKALI.—This discovery, which I think of great importance, cannot fail to occasion considerable changes in the systems of natural history, till now established, and will serve to illustrate various phenomena in the mineral as well as in the vegetable kingdom.

The following experiments will shew the particulars.

# (I.)

- a) Two hundred grains of finely triturated leucite were extracted, by repeated digestion with muriatic acid. The siliceous earth, collected on the filter, and lixiviated, weighed 109 grains after ignition.
- b) The muriatic folution had a yellowish colour. When, evaporated in a fand-heat, to the confiftence of honey, I obferved its furface covered with a pretty strong saline crust. After complete cooling, the mass appeared like a thick, golden-yellow, clear oil, full of crystals, partly of a cubical, partly of a tabular form. I gently poured off the yellow fluid, and rinfed the falt with small portions of alkohol. The folution, diluted with alkohol, was then evaporated afresh, and the small quantity of falt, which it afforded, again washed with ardent spirit, and added to the first. The salt thus obtained, and highly deficcated, weighed 70 grains. This I dissolved in water, adding some drops of ammoniac, which still separated some particles of aluminous earth. The folution was then again made to crystallize in a warm place, and it afforded only cubical crystals, some of which were lengthened to quadrilateral columns.
- fhoot into crystals, was diluted with water, and decomposed

in a boiling heat by carbonated foda. The precipitate confisted of aluminous earth, weighing  $47\frac{3}{4}$  grains, when depurated, washed, dried, and ignited. Upon this I poured three times its weight of concentrated sulphuric acid, and evaporated the mixture to a moderate dryness. The mass re-dissolved in water, then combined with a solution of acetated pot-ash, and set to crystallize, shot entirely into alum.

d) I mixed the filiceous earth, obtained at (a), with double its weight of pot-ash, and kept it in a strong red-heat for the length of one hour. The mass, which had but moderately coalesced, was ground, diluted with water, superfaturated with muriatic acid, and digested. By saturation with mineral alkali or soda, the siltered muriatic solution still afforded 1½ grain of aluminous earth; which being subtracted from the first weight of the siliceous earth (a), there remainded, for this last, 107½ grains.

From those decomposed 200 grains of leucite have, consequently, been obtained:

Alumine	c) 47 <sup>3</sup> / <sub>4</sub>	107,50
	494	49,25
and -	eletar Propo	35675

With a view of discovering its basis, I subjected it to the following trials:

- r.) Its taste and the figure of its crystals were found to be precisely the same with those of muriated pot-ash, or digestive salt, as it is termed.
- 2.) No change was effected either in the blue, or in the reddened litmus paper, by its folution.
- 3.) It made a crackling noise, when heated to redness, and remained behind as a body fixed in the fire.
- 4.) Its folution was not rendered turbid, either by carbonated foda, or by caustic ammoniac.
- 5.) Having poured two parts of strong sulphuric acid upon three of that salt, I caused the muriatic acid to evaporate, by means of heat, re-dissolved the mass in water, and obtained sulphat of pot-ash (vitriolated tartar) in its usual crystals.
- 6.) The portion of falt which yet remained I diffolved in a little water, and treated it with a concentrated aqueous folution of pure crystallized acid of tartar. Cream of tartar, or acidulous tartarite of pot-ash, was, by this management, immediately produced, which fell to the bottom in the form of sand. This was washed, dried, and burnt in a silver crucible; and when the coal which it produced was lixiviated, and the clear lixivium evaporated to a dry salt, it proved by every test that was applied to be a carbonat of pot-ash. By saturation with nitric acid, it shot into prismatic nitre, (nitrat of potash).

Therefore, the basis of those 70 grains of salt confisted solely of pure vegetable alkali, which had been neutralized by a proportionate part of the muriatic acid employed in the composition of the sossil. If now, as Bergmann afterts,

afferts, the alkaline basis of muriated pot-ash amounts to 61 parts in an hundred of the compound, the above mentioned 70 grains (a) contained 42,7 grains of pot-ash. And thus the 43,25 grains, before wanted to make up the 200 grains of leucite analysed, are accounted for to within a trisling deficiency.

Consequently by the results of this analysis, accomplished by muriatic acid, hundred parts of leucite consist of:

			99,725
Pot-ash	. 1		21,350
Alumine			24,625
Silex .			53,750

(2.)

- a) Three hundred grains of leucite, reduced to a most subtle powder, were repeatedly digested, by boiling with sour ounces of nitric acid. The filiceous earth, when separated by filtration, and ignited, weighed 162½ grains.
- b) This nitric folution was next evaporated. At first it continued colourless; but towards the end it turned a little yellowish, and after refrigeration it appeared like clear, tenacious turpentine. When diluted with water, and evaporated to but a moderate degree, it congealed into a greafy saline mass, consisting of small prismatic crystals. It was then successively treated and washed with alkohol, until the salt remained in a purified state. To the solution of this salt in water a sew drops of ammoniac were added; to free it from a slight portion of earth which still adhered,

and which was thus thrown down, and afterwards collected on the filter. After this, the whole of the faline folution, which was now as limpid as water, by flow exhalation has shot into prismatic hexahedral crystals, weighing 123 grains, after thorough desiccation.

- c) That portion of the above nitric folution, which remained mixed with the spirit of wine, and refused to crystallize, was diluted with water, and, in a boiling state precipitated, by the addition of carbonated foda. earthy ingredient fell down in a flimy, swelled form .-This, when previously washed and dissiccated, together with the foregoing flight portion of earth (b), was treated with distilled vinegar, and kept for a while in a warm place. The acetic acid was then neutralized by caustic ammoniac; and the earth, precipitated afresh, collected on the filter, again washed, dried, and ignited; in which flate it weighed 703 grains. It now presented itself in the character of the most pure aluminous earth; for, when diffolved by fulphuric acid, combined with acetite of potash, and crystallized, it yielded nothing but sulphat of alumine.
- d) Having collected the edulcorating water, I concentrated it by evaporation, and treated it, while boiling, with mild foda. But no further precipitation took place.
- e) The above mentioned  $162\frac{1}{2}$  grains of filex were mixed with twice their weight of effloresced soda, and along with it ignited for two hours in a silver pot. Upon the mass, when softened with a little water, an overproportion of muriatic acid was added, and the whole, after some digestion, diluted with water, and thrown upon the filter. On saturating the muriatic sluid with soda, a yellowish white precipitate arose, which, after heating to redness,

redness, weighed two grains, and was alumine, coloured by iron. As these should be subtracted, there are only 160½ grains to be put in the account for the filiceous earth.

It then appears, that in this analytical process, the alkaline-faline conflituent ingredient in the leucite was neutralized with the requisite quantity of nitric acid, and generated true nitre. But that the above constituent part is really and undoubtedly of the very same quality and nature with the vegetable alkali, has been evinced by the following examinations.

- 1.) The taste and crystalline figure of this salt perfectly agree with those of common nitre.
- 2.) When its folution had been combined with a folution of nitrated filver, or with that of acetated barytes, it continued bright and clear. This fact shews, that in the natural mixture of leucite, this alkaline-saline constituent part is contained, not accidentally and merely by the affishance of carbonic or sulphuric acid, by which it may be neutralized, but rather in a perfectly pure state.
- 3.) Upon a part of that falt I affused half its quantity of strong sulphuric acid, and carried on its evaporation until the nitric acid had been totally expelled. And when, after this, the residue had been re-dissolved in water, and crystallized, it produced sulphat of pot-ash in its usual crystalline form.
- 4.) The portion that remained I introduced into a small porcelain-vessel, and heated it to sussion, adding by degrees powdered charcoal in small portions, as long as any detonation took place.—The saline mass remaining consisted of carbanated pot-ash: and upon saturating it anew with ni-

tric acid, it formed again prismatic nitrat of pot-ash; in the same manner, as vitrialated tartar was produced from it by means of sulphuric acid, and digestive salt by means of the muriatic.

Concerning the alkaline basis of nitre, I shall take for a standard the proportion stated by Bergmann, according to which 100 parts of prismatic nitre contain 49 of vegetable alkali. With this, likewise, Wenzel very nearly agrees, as he reckons  $48\frac{1}{3}$  of pot-ash in 100 of nitre, and this small difference probably depends on this circumstance, that the latter weighed his nitre in the ignited state. As, therefore, upon this ground of calculation, the above mentioned 123 grains of nitre (b) contain 60,27 grains of vegetable alkali, the proportion of the constituent parts in 300 grains of decomposed leucite are as follow:

Silex . Alumine					4 4	160,50
Pot-alb	EQ .	 LOS I	<b>310</b>			72,75
many III		- A.		10 12 3	A SE	293,52

Or in one hundred:

0.1	7 7 7 6 7		
Silex.		0 0	53,50
Alumine			24,25
Pot-ash			20, 9
	4		-
A)1-3	1000		97,84

(3.)

I attempted also the resolution of leucite into its principles, by means of fulphuric acid.

- a) Two hundred grains of finely pulverized leucite were evaporated nearly to dryness, in a mixture of 200 grains of concentrated sulphuric acid with double its quantity of water. From the mass, again liquested with water, the filiceous earth was separated by filtering. It weighed 59 grains, and shewed by this, that it still contained some grains of undecomposed leucite.
- b) The colourless solution afforded, by evaporation, a clear, tenacious mass; which, when again dissolved in water, presently shot, without any surther addition, into regular sulphat of alumine, weighing 128 grains.
- c) This alum I exposed to a red-heat, and boiled the residue, previously powdered, with water; subtracting at the same time the predominant part of the acid, by saturation with powdered oyster-shells. The filtered and clear solution, being upon this evaporated, so as to crystallize, gave sulphat of pot-ash.
- d) The remainder of the fulphuric folution (b) has congealed, on farther evaporation, into a greafy, finely radiated mass.

### THIRD SECTION.

In all the preceding experiments the leucite from Vefuvius alone was employed. But as leucites are found in various other parts of Italy, it was an interesting point for me to

learn, whether, and how far, the constituent parts of these last agree with those of the foregoing.

With this view, I felected the leucite of Albano, near Rome.\* The specimens I have obtained of it consist of solitary grains, of the fize of green or sweet pease, and larger. Their exterior colour is a yellowish-white, and their crystalline figure is for the most part indistinct, owing to the edges and angles being worn off by friction; whereas the Vesuvian leucite is externally dull, and of an assumption, and commonly occurs with uninjured angles and edges.—The leucite from Albano, on the contrary, is clearer, more translucid, and more free from hornblende, in its interior mass, than that from Mount Vesuvius.

I found its specific gravity to be 2,490.

- a) An hundred grains of leucite from Albano, in a fine pulverulent state, were boiled with muriatic acid, and left behind them undissolved filiceous earth, which, after ignition, amounted to 54 grains.
- b) The muriatic folution was next evaporated to dryness on a fand-heat, and the yellowish-white residue, covered with alkohol, was exposed to a warm temperature, in a high cylindrical glass. After it had cooled, I decanted the spirituous solution of the muriated alumine from the muriat of pot-ash, which lay at the bottom as a white crystalline

<sup>\*)</sup> I acknowledge my thanks for the communication of this, and a great part of the foregoing leucite to Count Lepel, and Dr. Thompson, of Naples. It was by this augmentation of my little stock of this fossil that I was enabled to carry my analytical processes to complete evidence.

powder; and when the alkohol had evaporated in a warm temperature, I dissolved again the residue in ardent spirit, and added the small portion of muriated pot-ash, which still subsided, to the preceding. The whole quantity of it obtained was 36 grains; of which, according to what has been said before (page 357), 22 grains are vegetable alkali, constituting its basis. By solution in water, and perfect purissication by means of a few drops of ammoniac, and subsequent evaporation at a raised temperature, it separated in pure cubic crystals. These being re-dissolved, and combined with acid of tartar, produced cream of tartar; which, after ignition and lixiviation, afforded carbonated pot-ash.

c) The muriat of alumine, that was held in folution by the alkohol (b), was diluted with water, and decomposed by ammoniac. The aluminous earth, thus precipitated, amounted to about 23 grains, when washed, dried, and ignited.

These hundred grains of leucite from Albano were therefore resolved into:

Silex			a)		1.		54
Alumine							
Pot-ash		0 1	b)			1.	22
				,			00

### FOURTH SECTION.

THE inferences refulting from the above experiments might be in some degree questioned by those philosophers, who consider the basaltic matrix of leucite, as well as all basalts in general, as lavas, and hence would think themselves entitled to doubt the primitive origin of leucite, and the originality of its alkaline constituent

stituent part now discovered. Therefore, in order at once to obviate every possible objection, I resolved to investigate whether a leucite, the mixture of which must be acknowledged as not volcanized, even by the most obstinate Volcanists, would contain pot-ash in its natural mixture as a constituent part, though hitherto this alkali has been confidered as belonging only to the vegetable kingdom. For this purpose, I selected that irregularly shaped, finelygrained, foliated leucite, mentioned at the beginning of this Essay, which either accompanies the stony masses, compounded of mica, shörl, vesuvian, calcareous spar, &c. that are ejected by Vesuvius in their original rough state; or which is concreted with them. Of these specimens, I separated for this inquiry a fufficient quantity of leucite in a lump or mass, and performed its analysis according to the method before described.

By the process I obtained, besides filex and alumine, a cubically crystallized muriated neutral salt, whose alkaline basis shewed itself to be vegetable alkali, from the circumstance of its producing cream of tartar, by combination with tartareous acid.

This enquiry into the constituent parts of that variety of leucite was satisfactory; though the determination of their proportions could not be accomplished with due accuracy, on account of the black needles of short, small waxyellow grains of vesuvian, and the like, with which it was too abundantly mixed.

### FIFTH SECTION.

(1.)

As the preceding analyses were all performed with those species of leucite, which remained in their unaltered original

ginal state, it remained to complete the subject by the examination of a leucite, which had sustained the action of a volcanic fire.

The specimen of leucite subjected to this experiment was picked up at *Pompeji*, and belongs to the most common varieties. It consists of detached grains, for the most part of the size of a pepper-corn. Its interior surface, like the exterior, is ash-grey, of an earthy appearance, and wholly opake; and it may be easily comminuted to a sandy powder.

Hundred grains of it, decomposed by muriatic acid, exactly in the same manner as the leucite from Albano in the third section, and the muriat of pot-ash thereby obtained, calculated for its basis of vegetable alkali, have afforded:

			97,50
Pot-ash		•	19,50
Alumine			23,50
Silex .			54,50

It remains for repeated experiments to decide, whether it is merely accidental, that the proportion of the alkaline ingredient, in this instance, is less than usual; or whether this diminution takes place regularly in every leucite, altered by volcanic fire.

# (2.)

In this place I shall, moreover, briefly notice a particular variety of leucite, which occurs at Ronciglione. It is found

found of middle-fized, infulated grains, presenting sometimes traces of their original crystalline form. Those grains are whitish, inclining to the isabella-yellow; they are entirely opake, of an earthy look, and very easily friable. When thus comminuted, they do not yield such a harsh sandy powder, as is obtained from grains of volcanized leucite, but a soft powder resembling argillaceous earth.—It seems, therefore, that they have not suffered any change by the fire; but have rather undergone a high degree of decay, caused by the joint action of water and air; and finally, that, by this alteration, they have been brought near to their complete spontaneous decomposition, or resolution into their component principles.

The flock which I had of them was too small to admit of a complete examination; which, however, I think they deserve, for the purpose of discovering, whether in this state of great decay, they had suffered any loss of that alkaline ingredient, which was before unknown in the mineral kingdom.

I now flatter myself with the hope, that, by the experiments here communicated, and several times repeated, I have fully demonstrated the existence of pot-ash in the leucite, as one of its chemical constituent parts. Nevertheless, I am contented to defer the general reception of this new discovery till several other chemical naturalists have re-examined and confirmed it. This trial may be the sooner expected, since my method of proceeding in the main object of this investigation is attended neither with laborious operations, nor with much loss of time.

But if that alkali, as foon as it can no longer be confidered as a fubitance, produced only in the juices of plants during their their vegetation, be required to occupy a more fuitable place among the original, fimple mineral fubflances, it will then likewife be necessary to give it a more appropriate name.

The term Pot-ash, which, in the new chemical nomenclature, is raised to a generic name, cannot among us Germans claim a general acceptation; as its origin depends on a trivial etymological ground, and has been introduced into use merely from this circumstance, that formerly, instead of calcining surnaces, iron pots were employed to ignite the inspissance lyes procured from wood-ashes.

I should wish to recommend, that the denominations hitherto used, of vegetable alkali, lixiviated vegetable salt, pot-ash, &c. be discarded, and the name KALI\* be employed in their stead. In like manner should the appellations, mineral alkali, soda, &c. denoting the alkaline basis of common salt, give place to its ancient name,—NATRON.

<sup>\*)</sup> This has been done by the London Royal College of Phyficians in the year 1787. They have introduced in their Pharmacopæia both these names, kali and natron, here recommended by Klaproth. The Edinburgh Dispensatory, on the other hand, calls the first lixiva, and the second soda.—However, the terms, pot-ash and soda, being at present more familiar to modern English chemists, the Translator has, for the most part, given them the presence.—Transl.

#### XXXIII.

#### CHEMICAL EXAMINATION

OF

#### PUMICE-STONE.

HE Pumice-stone belongs to those mineral bodies, on the origin and formation of which the opinions of philosophers are yet divided. Various passages in the works of Theophrastus, Dioscorides, Pliny, and Galen, concerning this substance, shew fufficiently, that, even in remoter ages, Naturalists have thought it worth their confideration. One of the principal foundations abfolutely necessary to be laid down by the inquiring Geogolist, if he wishes to raise with fuccess the edifice of his theories, undoubtedly confifts in a just and accurate chemical knowledge of his object. This knowledge has, however, been hitherto wanting, with regard to pumice-stone. For, although various analyses of it have been published, there still occurs a very important difference in the enumerations of its constituent parts: fo much fo, that the Mineralogist is at a loss to know, which of them he is to follow in the arrangement of fossils.

Many of those who have analysed the pumice stone, enosider it, with Bergmann,\* as an asbest changed in its mixture by a volcanic fire. This opinion seemed to be justified, partly by its sibrous texture, partly, and especially,

<sup>\*</sup> Bergmann Opusc. Phys. et Chemic. vol. III. p. 197.

by the portion of magnefia, that has been supposed to exist in it. But, notwithstanding that Bergmann, Cartheuser\*, and but very lately Spallanzani+, have mentioned the magnesian earth, in their analyses of pumice-stone, as a constituent part,—I am convinced, by my own experience, that it does not, in the least, enter into this fossil. The supposed origin of pumice-stone from asbest is, therefore, unfounded; and, along with this false derivation, likewise, another difficulty of some weight is removed, which seemed to oppose the instructive theory of the matrices of pumice-stone given by Nose ‡.

a) Common, grey-white, fibrous pumice-stone, swiming on water, and procured from Lipari, was ground, and boiled with water. The water boiled with it was found to have extracted nothing; only, by treatment with nitrated silver, it gave a slight indication of muriatic acid.

Hundred grains of this pumice-stone, gently ignited, and finely pulverized after decoction, were exposed to a redheat, with twice their weight of caustic alkalı, during half an hour. The mass returned from the fire of a bright grass-green colour; by which it was found to contain a small portion of manganese. After having been softened with water, this colour changed to a foul light-brown. It was then digested with dilute muriatic acid. Siliceous earth separated in this process; which, collected on the filter, and finally heated to redness, weighed 77½ grains.

b) What had been diffolved by the acid was next precipitated by caustic ammoniac, and the brownish precipi-

<sup>\*</sup> Cartbeuser, Mineralogische Abhandlungen, Th. II. p. 136.

<sup>†</sup> Spallanzani's Travels into both Sicilies, vol. II.

<sup>†</sup> Orographische Briefe, vol. II. page 185 and others. Also Sammlung einiger Schriften über Vulkanische Gegenstände a. d. Basalt, page 271.

tate collected on the filter. The fluid separated from it, contained no extraneous matter.

- c) Hot caustic lye directly diffolved that precipitate, leaving an oxyd of iron behind it, the quantity of which, after ignition, was 13/4 grains.
- d) The alkaline folution, previously super-saturated with muriatic acid, was combined with carbonated alkali. Thus, the earth which it held dissolved was precipitated. When edulcorated, and heated to redness, it weighed 17½ grains. It proved to be pure aluminous earth; for, on being redissolved in sulphuric acid, and combined with an adequate portion of liquid acetated pot-ash, it afforded nothing but alum.

In consequence of this, the constituent parts, discovered in the common punice-stone from Lipari, are:

Silex .							
Alumine							
Oxyd of ire	n	the 3		c)	1940, 9		1,75
Besides a t	race of	mang	ganese	a)			
						9.	-6

96,75

It is worth remarking the small degree of solvent power which acids exert on rough pumice-stone. Although I had digested 100 grains of finely-ground pumice-stone with twelve times its quantity of muriatic acid, affished by a boiling heat, yet it was hardly attacked. The acid, indeed, was tinged of a faint yellow; however, at most, there appeared only a few loose, brownish slocculi, which, when most carefully collected, scarcely amounted to \( \frac{1}{8} \) of a grain, and consisted, for the greatest part, of oxyd of manganese. The sulphuric acid proved to be as little capable of affecting rough pumice-stone as the muriatic.

# [ 371 ]

#### XXXIV.

#### CHEMICAL EXAMINATION

OF THE

# TERRA AUSTRALIS (Sidney-earth).

A few years fince, the public has become acquainted with an arenaceous, or fandy fossil, under the name Australfand, which has been found near Sidney-cove, in Now South-Wales, and was brought from thence to England. This fosfil has been afferted to contain a new, distinct, peculiar earth, denominated Austral-earth (Sidneia, Cambria), upon the ground of its analysis made and published by Fos. Wedgwood \*; of which the following are the principal particulars. The principal character of that earth is faid to be, that it resists all acid and alkaline menstrua, ftrong muriatic acid only excepted, which alone, by means of repeated digestion, takes up this earth from that arenaceous fossil. It is also said to be again precipitated from its muriatic folution, merely by dilution with water; and to be, after this, absolutely insoluble in any other solvent but the muriatic acid, with the affiftance of heat.

My defire of acquiring information on this subject by my own experience has continued till now unaccomplished. It is only of late that I was fortunate enough to receive a quantity of austral-sand; little, indeed, yet sufficient for an examination sparingly managed. The specimens obtained

<sup>\*</sup> Philosophical Transactions, vol. lxxx. 1790.

were of two forts. One of them was mixed with a greater proportion of those black, shining lamellæ, that are taken for graphite, but, to my conjecture, are rather slakes, or scales, of ferruginous mica. The other fort was purer, and had less of the substance just mentioned. For this reason I employed only this in the present inquiry.

- a) I triturated thirty grains of it to a most impalpable powder. The original grey-whitish colour of that fossil changed thereby to a blueish, owing to a more minute division of the particles of ferruginous mica. Strong muriatic acid was then affused upon the powder, and digested with it for a considerable time, in a heat of ebullition. After cooling, the acid was decanted from the sediment, and this last digested with a fresh quantity of the same acid. This operation was reiterated a third time.
- b) When the acid had been filtered clear, through a double-folded printing-paper, I diluted it gradually with a large quantity of water; but not the least turbidness nor precipitation ensued. I exposed the mixture to a warm temperature; yet still it remained clear and limpid, like water.
- c) The muriatic liquor was then faturated with carbonat of pot-ash. This threw down a few light particles, which, collected on the filter, washed, and dried, weighed 3½ grains. They also dissolved in dilute sulphuric acid, but left behind a slight portion of silex, and formed with that acid crystals of alum.
- d) The refidue left on the extraction with muriatic acid was ignited with three parts of carbonated pot-ash, then again treated with muriatic acid, and its insoluble slimy portion separated by filtration. This last consisted of silex, weighing 19½ grains, when edulcorated and ignited.

e) The

- \*) The muriatic folution was then tried with pruffiated pot-ash. The blue precipitate hereby produced indicated about \( \frac{1}{4} \) grain of iron.
- f) By combining afterwards the folution with carbonated pot-ash, aluminous earth was precipitated; which, after ignition, weighed 8½ grains, and, upon solution in sulphuric acid, entirely crystallized into sulphat of alumine.

Silex, alumine, and a little iron, therefore, were all the principles I was able to discover in the austral-sand here examined; and no trace of any other constituent ingredient appeared.

Although in this inquiry I have been obliged to confine myfelf to the small quantity of 30 grains, without being able to repeat it for want of a greater stock of this mineral, yet its result is sufficient to excite a very reasonable doubt of the real existence of such a new earth as is pretended to be met with in austral-sand. Time will shew whether this doubt may be removed, or confirmed, by repeated and more accurate analyses. If the last should be the case, the illusion which led to that erroneous supposition may, perhaps, be explained in the following manner:—

Mr. Wedgwood does not tell whether he had filtered, to perfect clearness, the muriatic acid employed for the extraction of the fosfil, and previously to its being mixed with water. The contrary seems rather to have taken place; for he says that the sluid turned white when he added water to the acid, for the purpose of diluting the acid, and edulcorating its remaining part. It is therefore probable that the earth, let fall by the acid on the admixture of water, was nothing else but alumine still chemically combined with silex, which, during the long and hot digestion, had been taken

### 374 XXXIV. Chemical Examination, &c.

taken up by the muriatic acid, and was now deposited in the water.

Finally, that the fossil here examined was genuine australsand, is warranted by the hand from which I received it. It was Mr. Haidinger, from Vienna, who kindly gave it me on his return from London, where he obtained it from the Right Hon. Sir Foseph Banks, Bart.\*

<sup>\*</sup> Since that time Charles Hatchett, Efq. F. R. S. of London, has likewife analysed the terra australis, and found it to contain so new earth, but to be a compound of silex, alumine, oxyd of iron, and plumbago. His paper is printed in the Philosophical Transactions for the year 1798.—Transl.

### XXXV.

### CHEMICAL EXAMINATION

OF THE

# GRANULAR SULPHATED BARYTES, From Peggau.

THE granular baroselenite, or fulphat of barytes, is one of the rarer species of this genus of ponderous earth. That of Peggau, in Stiria, which is the subject of this essay, occurs of a beautiful milk-white colour, is massive, resplendent, finely-grained, semi-indurated, and brittle. It bears a very strong resemblance to the white, sine-grained Carara-marble; to such a degree, that, by its mere appearance, it might easily be mistaken for it, were it not for its greater specific gravity, which is 4,380, and by which it is readily distinguished.

### A

- a) It loses nothing of its weight by ignition.
- b) When pulverized, and boiled with a large quantity of water, it imparts to this last nothing observable by the sight, taste, or smell. Of all the re-agents, only the solution of silver in nitric acid rendered the water boiled with it in a slight degree opalescent.
- c) In like manner, nothing of it was diffolved by digestion with muriatic acid. The only exception from this is an unimportant trace of iron, which was detected by Prussian alkali.

### В.

a) Two hundred grains of this fossil, mixed with 500 grains of carbonated pot-ash, were subjected, for two bb4 hours,

hours, to a moderately ftrong red-heat. The mass, which only conglutinated, was then pulverized, boiled with water, and the remaining earth collected upon the filter.

- b) The alkaline fluid contained fome filiceous earth, befides the fulphuric acid of the barytes. To feparate that earth, the fluid was fully neutralized by muriatic acid, and evaporated to dryness. The filex remaining, after the refolution of the faline mass in water, weighed 18 grains upon ignition.
- c) The barytic earth freed from the sulphuric acid (b) was covered with water, and combined with muriatic acid. After some digestion, the whole was sound dissolved, except a remainder of siliceous earth, of two grains weight, when ignited. When this last had been separated, I caused the filtered solution to crystallize, by the usual management; and it afforded, to the end, only muriat of barytes, partly in rhomboidal, partly in oblong six-sided tables.
- d) All these crystals I dissolved again in water, and dropped sulphuric acid into the solution only as long as it produced any precipitate. The regenerated sulphat of barytes, when collected, washed, and dried, weighed 185 grains; but, when heated to redness, no more than 180 grains.

The mixture of this fossil, in one hundred parts, therefore, consists of:

Pure	<i>[ulp]</i>	hat	of	bary	ytes	d)			90
Silex						b)	97		10
Entella manual						c)	17		

100

Or, because in the ignited ponderous spar, or sulphat of barytes, the earth is to the acid very nearly in the proportion of 2 to 1, the above fossil consists of:

Barytes Sulphuric acid (free Silex	e from water)	
		100

### XXXVI.

### CHEMICAL EXAMINATION

OF THE

# TESTACEOUS SULPHAT OF BARYTES,

From Freiberg\*.

IT was, undoubtedly, the powerful attraction which the barytic earth has for fulphuric acid, exceeding even that of the pure fixed alkalis, that induced the deferving Scheele, who first discovered it as a distinct earth, to think that an alkaline salt is incapable of resolving the natural mixture of baroselenite into its separate principles. On this account, when attempting to expel its sulphuric acid, he resorted to the impersect and tedious process of repeatedly working the stone to a passe, with honey or oil, of calcining that mass by means of the muriatic or nitric acids, and, at last, of extracting such a part of it as had been disengaged from the sulphuric.

Yet there are feveral inflances where the unaffifted force of attraction of pure alkali has been too weak to feparate

<sup>\*</sup> Chemisch. Annal. 1796. I. B. S. 387. It is, properly, a variety of common ponderous spar. Kirwan calls it Baroselenite. The author, with the rest of the Germans, and some French, calls it (schalig) testaceous, from its form, pretty equally spreading in length and breadth, but, comparatively, of inconsiderable thickness. Emmerling has given a masterly detailed description of its figure and varieties. See his Lehrbuch der Mineralogie, Giessen 1793. Vol. I. page 557. seq.—Transl.

# Of the testaceous Sulphat of Barytes, &c. 379

the component principles of mixed bodies; while, on the contrary, when they have been employed in the carbonated, or otherwise neutralized state, the desired object has been attained by this new increase of attractive force.

This is the very case with ponderous spar, and is sounded on the method learnt of Wiegleb: which is, to decompose it in a shorter, cleanlier, and more complete manner, by igniting it with carbonat of pot-ash. This method, as to the most essential part, has since been universally approved and adopted.

It feems, however, to be the common opinion, that this decomposition obtains, in the *dry way* only, and that the feparation of fulphuric acid from barytes absolutely wants the support of red-heat; as, to my knowledge, no one has yet attempted the *humid way*, to effect it.

### A.

a) A thousand grains of common, white, thick, testaceous baroselenite\*, in the purest selected pieces from the mine Kurprinz Frederick August, near Freiberg (in Saxony), were triturated with water to the finest powder, and then boiled for one hour, in a filver pan, with twice their weight of carbonated pot ash, and five of water, stirring them occasionally, and supplying the loss of water as it evoporated; which being done, more water was added, and the whole filtered. The residue weighed 910 grains, after washing and exsiccation. Muriatic acid was affused upon it successively, until all effervescence ceased. After gentle di-

<sup>\*</sup> Thick-testaceous (Dickschalig), when from \( \frac{1}{2} \) an inch thick,--Transl

gestion, the muriatic acid was filtered off from the still undecomposed barytic sulphat, which, upon washing and drying, weighed 426 grains.

- b) With this remainder of sulphated barytes, the same process of coction with double its quantity of carbonated pot-ash, and five times that of water, was repeated.—The edulcorated powder amounted to 387 grains; of which, after extraction of the foluble part of earth by muriatic acid, there remained 198 grains still undecompounded.
- c) These 198 grains, treated in the same manner with alkali and water, gave then 183 grains. Of these, the muriatic acid lest again 128 grains of undecomposed sulphat of barytes.
- d) When these had been boiled with pot-ash and water, in the manner mentioned before, there remained 122 grains; which muriatic acid diffolved, excepting a remainder of 96 grains.
- e) After a new subsequent decoction with twice the quantity of alkali and water, there remained 90 grains; of which, upon extraction performed with muriatic acid, there appeared a residue of 72 grains; which,
- f) Upon repeating the boiling with carbonic pot-ash, left 69 grains of powder, and, after extraction by muriatic acid, 61 grains.
- g) As I thus observed that the success of the decomposition of ponderous spar decreases in the proportion of its diminished quantity, I had recourse to the dry way for the final analysis of that residue. For this purpose I mixed it with three times its weight of mild alkali, or carbonated

pot-ash, calcining the mixture in a filver-vessel during the space of half an hour. After softening the mass, there remained 50 grains of edulcorated residue; which now totally dissolved in muriatic acid, only sive grains of unattacked silex excepted.

The alkaline lixivium, obtained from that ignited mass, and somewhat reduced by evaporating, then afforded three grains of filiceous earth.

- b) I then evaporated, together, all the muriatic folutions mentioned before, to the point of crystallization; and they yielded, at the first two shootings, the muriated barytes in a perfectly pure state.
- i) The remaining folution feemed to exhibit figns of the presence of some iron. It was therefore saturated with caustic ammoniac, and filtered. There collected on the paper a brownish earth, which, when highly dried, weighed I<sup>1</sup>/<sub>2</sub> grain. Yet, notwithstanding this small quantity, it was not mere oxyd of iron; for, when dissolved in muriatic acid, and treated by Prussian alkali, the sluid remaining, after the separation of the blue precipitate, yielded half a grain of alumine, by combination with ammoniac. The portion of iron, therefore, amounted only to one grain.
- k) The remainder of the folution of muriated barytes, being thus freed from those foreign ingredients, was decomposed by means of mild ammoniac. I then re-dissolved the precipitated earth in muriatic acid, and put it in a gentle temperature for farther crystallization. Pure muriat of barytes crystallized, as long as the solution contained one drachm of it; upon which I committed it to spontaneous exhalation in the open air. It crystallized entirely, without leaving any drop of liquor, to regular crystals; of

which

# 382 XXXVI. Of the testaceous Sulphat

which the first shooting still consisted of some tables of muriated barytes, but the subsequent ones afforded needle-shaped crystals of muriated strontian-earth.

- I) Upon this, I carefully collected the crystallized muriat of strontian, dissolved it again in water, and re-produced it again in its former state of *fulphated strontian-earth*, by dropping sulphuric acid into the solution. The sulphat, washed and dried, weighed  $8\frac{1}{2}$  grains.
- m) The whole of the crystallized muriat of barytes, which was collected, amounted to 18 drachms.
- n) Another portion of a thousand grains of sulphated barytes, ground to a moderately fine powder, and subjected to intense red-heat for half an hour in a porcelain-crucible, lost no more than seven grains of their weight; which loss may probably have consisted only of the aqueous particles driven out in the process.

It refults from these experiments, that the white, testaceous sulphat of barytes, in pieces selected of the utmost purity, and from the mine mentioned above, reckoning with a thousand parts, is composed of:

Sulphate	d bar	yte	5						97	75
	- Sti	ron	tian	2-00	arth	-0				8,5
Silex .										8
Oxyd of	iron						,			I
Alumine										0,5
Water										7
								Company		-
									IO	00

B.

The refult of this analysis, therefore, demonstrates, that the *humid way* is likewise applicable in the decomposition of ponderous spar, by means of alternate boiling with a concentrated aqueous solution of carbonated pot-ash, and subsequent solution in any suitable acid.

This management affords, especially in operations performed with great quantities, a double advantage. The first is, the saving of crucibles, which would be otherwise destroyed; the second is this, that the remaining alkali, which ought to be recovered after the separation of the newly-formed neutral sulphat, is not liable to be contaminated in this method.

When ponderous spar is ignited or sused with pot-ash, that part of the alkali which is not neutralized, during the process, by the sulphuric acid of the fossil, will attack not only the siliceous and argillaceous earth, which are usually contained in the ponderous spar, but also that which enters into the substance of the crucible. It will also retain a great part of those earths, in a dissolved state, in proportion as the alkali, during ignition, gives out its carbonic acid, and becomes more or less caustic. On the contrary, if the process of boiling be employed, no transition takes place in the alkali, from the mild or carbonated, into the caustic or pure state; hence also no contamination of it with silex and alumine will arise.

### XXXVII.

### CHEMICAL EXAMINATION

OF THE

CROSS-STONE (Staurolite.)

THE chemical analysis of that fossil, which is found at Andreasberg, on the Harz, and has the name of cross-stone, cross-crystal (staurolithus), and consists of double crystals, concreted in the form of a cross, has already been instituted by two eminent chemists, Heyer and Westrumb. Both have long ago published their analyses. It might therefore be deemed needless to add mine, if the following reasons did not excuse it.

It is well known, that both these chemists have sound barytes, besides silex and alumine, among the constituent parts of that sossil. To suppose the presence of barytes, in this instance, Westrumb was satisfied with the observation, that, by combination with sulphuric acid, this earth forms a precipitate of difficult solution in water. From the state of chemical knowledge of the simple earths at that time, it was indeed allowable, to consider such a precipitate, directly and without trial, as sulphated barytes.

But fince we have become acquainted with strontianearth, which likewise combines with sulphuric acid to a difficultly soluble precipitate, that phenomenon alone is not sufficient to determine, whether a certain earth, met with in any process, be the barytic.

Heyer,

Heyer, on the contrary, when examining the staurolite, found this constituent part of it to crystallize both in the nitric and muriatic acids; from which he could, with greater confidence, suppose it to be of a barytic nature. But, as he has given no particular account of the figure of its crystals, especially of those formed with the muriatic acid, I thought that a fresh examination of this fossil might be a means to ascertain, whether the earth mentioned was really the barytic, or whether the strontian.

- a) One hundred grains of white crystals of the cross-stone, carefully freed by distilled vinegar from all adhering calcareous earth, were finely pulverized, and subjected to a low red-heat for half an hour, with a double quantity of carbonated pot-ash. The mass, which was then easy of trituration, was lixiviated with water, and left 109 grains behind.
- b) To this residuum was added the small portion of earth, which was still obtained from the alkaline lye, by saturating it with an acid, and evaporation. I then gently digested it with muriatic acid, with which it effervesced, and deposited siliceous earth, in a fine, sandy form, weighing 32 grains, after previous separation by the filter, and ignition.
- c) The muriatic folution, super-saturated with caustic ammoniac, gave a transparent, paste-like precipitate, which, upon edulcoration, drying, and ignition, weighed 33 grains. It consisted of alumine, but still mixed silex. For this reason, I combined it with sulphuric acid, and evaporated it to a moderately dry saline mass, which, again diluted with water, deposited siliceous earth, amounting to 17 grains, when heated to redness. The true quantity of aluminous earth, therefore, amounted to 16 grains.

# 386 XXXVII. Examination of Staurolite.

- d) The remaining folution was evaporated to a smaller volume, and the earth, which it still contained, was precipitated by means of carbonated pot-ash. This earth weighed 23 grains, when washed and dried. But when re-dissolved in muriatic acid, it shot, to the last drop, into tabular crystals of muriated barytes: proving, by this, to be true barytic earth.
- e) Since, in consequence of other experiments, those 23 grains of carbonated barytes are equal to 18 grains of pure barytes; since, moreover, the staurolite lost 15 per cent of the whole, on ignition, and, as this loss was probably mere water, the proportion of its constituent parts is as follows:

Silex .		b) c)	32	}.		49 grs.
Barytes						
Alumine						
Water.						
						98 grs.

### XXXVIII.

### SOME FARTHER RESEARCHES

CONCERNING

# WITHERITE and STRONTIANITE.

### FIRST SECTION.

### A

IT is needless to prove, that chemical analyses give more accurate results, the greater the quantity is of the substance subjected to decomposition. But, at the same time, it is not less evident, that the expence of the process increases in the same proportion. The chemist, therefore, who, besides time, trouble, and patience, frequently sacrifices a considerable sum to his love for the science, should not be censured for parsimony, if he can but seldom perform his analytical experiments with ounces and pounds, but must commonly restrain himself to smaller quantities.

The following researches on witherite may afford an inflance of what just now has been said.

a) Twelve ounces of witherite from Anglezark, (near Chorley, in Lancashire) coarsely powdered, were gradually dissolved in fifty ounces of a mixture, composed of one part of muriatic acid and three of water. Except a sew grains of sand, no residue was lest. The filtered solution, when set to crystallize, gradually afforded 14 ounces 5½ drachms of muriated barytes.

b) The

- b) The mother-water, remaining from that folution, had acquired a greenish colour; and, as likewise the crystals which last formed, seemed to tend a little to the green, I desiccated them in a high heat, washed them with alkohol, and added the washings to the remaining shuid; which I then treated with caustic ammoniac, added to excess of saturation. By this management, the solution was rendered sky-blue, and, at the same time, turbid, by a slight portion of earth which then separated. This last, collected, and dried in the air, weighed 2½ grains; had a yellowish-white colour, and was aluminous earth, mixed with iron.
- c) On super-saturating the filtered shuid with muriatic acid, the blue colour disappeared. I then treated it with pruffiat of pot-ash of the utmost purity. This produced a brown-red, tender precipitate, which I carefully gathered, washed, and desiccated. But this, besides that it was of so fmall a quantity, had so firmly adhered to the filtering paper, that it could not be accurately separated from it. It was, therefore, together with the paper, subjected to lowred heat, and the ashes were extracted by liquid carbonat of ammoniac, until the portions of this, fucceffively employed, ceased to be tinged blue. When upon this, the volatilealkaline tincture had been evaporated, there remained in the evaporating pan a bright-green, carbonated oxyd of copper, weighing half a grain; which diffolved in a few drops of dilute fulphuric acid, and immediately precipitated, in the reguline state, on a polished piece of iron, upon which it was dropped.
- d) The mother-water of the folution of the witherite (b), previously purified with cautic ammoniac and Prussian alkali, was next combined with mild alkali prepared from tartar; and the precipitate, that appeared of a dazzling white, being dissolved in muriatic acid, was left to sponta-

neous exhalation. Thus the folution conffantly afforded muriat of strontian-earth, in small hexahedral crystals; which, re-dissolved in water, and precipitated by carbonat of ammoniac, yielded 98 grains of carbonated strontian-earth.

These 12 ounces of witherite, which are equal to 5760 grains, consisted, therefore, of:

Carbonated barytes	
Carbonated oxyd of copper	0,50
and dried in the air	2,50
	5760 grs.

The foregoing analytical process serves to confirm the existence of a slight trace of copper in the English witherite, which has been already observed by Westrumb\*, as well as the presence of strontian-earth, both in the English and Siberian witherite, noticed by Lowitz+.

### B.

Hitherto, the only places where carbonated barytes is found native, are Anglezark, in England, and the Schlangenberg, in Siberia; for, the report of its occurrence in the metalliferous mountains of Saxony has not yet been confirmed. However, this fossil has of late also been discovered in a third place, which is the pit Steinbauer, near

<sup>\*</sup> Chemische Abhandlungen, von Westrumb, Hanover, 1793, vol. I. page 266.

<sup>†</sup> Chemische Annalen, 1795. I. Band. Seite 110.

Neuberg, in Upper-Stiria. It is found there in a Aratum of spatose iron-stone, partly massive, or in considerable lumps, and in part coarfely diffeminated in brown iron-ochre.

One hundred grains of this Stirian witherite dissolved completely, and with effervescence, in dilute muriatic acid. The whole of that folution shot into muriat of barytes, in tabular crystals; the aqueous folution of which was precipitated in the state of sulphated barytes, by means of sulphuric acid.

### SECOND SECTION.

THE attemps made to free witherite from its portion of carbonic acid, fimply by ignition, and to bring it thus to the perfectly caustic state, have hitherto miscarried, owing to its vitrifying with the mass of the clay-crucibles; and, on the other hand, its confuming, and, as it were, diffolving, those made of charcoal. On this account, I refolved to repeat the experiment with a veffel made of platina.

A piece of witherite, weighing 200 grains, was put in a platina crucible, previously weighed, and this last, when introduced into a faggar (caffette) made of clay, was conveyed into the middle chamber, or fire-place, of the porcelain-furnace; where the intensity of heat is at 136 degrees of Wedgwood's pyrometer. When the vessel had returned from the fire, I found the weight of its contents diminished 23 grains. The calcined witherite appeared as a dirty-brownish, coarse powder; which so firmly adhered to the bottom of the crucible, that it could not be detached without injuring the latter. I, therefore, tried whether I could foften the calcined witherite with water. But, although

though the water affused upon it became intensely heated, the separation of the stone proved so difficult, as to oblige me to affist it by a boiling heat. The calcined witherite left at the bottom of the platina crucible some slosulous impressions; and, in general, its internal polish suffered much, though the external remained unimpaired.

The loss of weight, amounting to 113 per cent, indicated that the witherite had not lost much above one half of its carbonic acid. It was owing to this, that it would not entirely dissolve in boiling water, and that the residue still considerably effervesced with acids.

In the filtered aqueous and clear folution of the calcined witherite, which had been directly preserved in a wellstopped bottle, I observed, after some days, that the barytic earth had crystallized in several small groups, between which various infulated crystals formed distinct octahedrons. In order to obtain a greater quantity of them, I reduced, by boiling, all the water impregnated with the ignited barytes to one fourth part; feparated by filtration the pellicle of carbonated barytes, which formed on the furface of the fluid during the process; and transferred the liquor, while yet hot, into a glass provided with a stopper. Before the water had thoroughly cooled, fimilar crystals were formed, which I found confiderably increased on the following day. Thus I faw with pleasure confirmed by my own experiments the fact, that calcined barytes is crystallizable in water; which property Vauquelin and Pelletier have of late, each in a different way, discovered at Paris.

B.

Since, therefore, according to this last experiment, the barytic earth agrees in this point with the strontian, it follows,

lows, that this property of any calcined earth to crystallize in mere water can no longer be confidered as an exclusive character of strontian-earth. But from this we can by no means conclude, that both these earths are identically the fame. Their effential difference, besides the other discriminating properties already known, principally depends on the specifically different degrees of affinity, or chemical attraction, shewn by each of them for the various acids. Of this, the following experiment furnishes a proof.

I mixed an aqueous folution of acicularly crystallized muriated strontian-earth with a solution of acetated barytes; evaporated the mixture to dryness; exposed the obtained faline mass to a strong red-heat in a crucible; re-dissolved that ignited refidue in water; promoted the crystallization of the filtered folution by the usual means, and obtained only muriated barytes, crystallized in quadrangular tables.

The muriatic acid, therefore, quitted the strontian-earth, and combined with barytes, with which it had a stronger affinity. - By this new demonstration of the effential difference of these two earths, deduced from the different degrees of their attractions for acids, it may be hoped, that chemists will no longer entertain any doubts concerning the exist ence of the strontian as a distinct earth.

C.

Before I conclude, I shall yet notice, in a few words, the relations of barytes to pruffiat of pot-ash. The precipitation, effected by this last, of barytic earth from those acids with which it forms foluble middle falts, has feveral times occafioned erroneous conclusions. It was upon this, that Bergmann and others have founded their hypothesis, ascribing a metallic nature to that earth, already refuted by more accurate examinations. With no better reason, has even lately one of the principal French chemists\* reckoned the precipitation of barytes by Prussian alkali among the characters which distinguish it from strontian earth.—However, this precipitation does not take place, except when the prussiated pot-ash employed is not entirely free from the neutral sulphat, which usually contaminates it; for, if the prussiat is perfectly pure, it is as little capable of precipitating barytes as any other of the simple earths. On this account, whenever I prepare Prussian alkali, to be used in accurate chemical experiments, I always repeat the processes of its purisication, until the solution of nitrated barytes is no longer, even in the least degree, rendered turbid by it.

<sup>\*</sup> Journal des Mines, N. xxi. Prairial, p. 45. feq.

[ 394 ]

### XXXIX.

### CHEMICAL EXAMINATION

OF THE

### SULPHATED STRONTIANITE

from Pensylvania\*.

AFTER the strontian-earth had been established as a peculiar, chemically-simple earth, it was to be expected, that it might likewise occur combined with sulphuric acid, instead of the carbonic, as is the strontianite from Scotland. This conjecture was already in part verified; as it has been found, that most of the ponderous spars contain sulphated strontian-earth in their mixture, though in only a small proportion, not amounting in the baroselenites, hitherto examined with this view, to more than from one to two per cent.

But the present analysis will fully prove the existence of a perfect natural sulphat of strontian-earth, without any portion of barytic ingredient.

The fossil, in which I discovered this combination, has been known but a few years. It was at first called, blue, fibrous gypsum, from Frankstown, in Pensylvania. The following are its distinctive characters.

<sup>\*</sup> Sulphat of firontian-earth (fironties) has also been discovered lately in the beach at Aust-passage, near Bristol, in Gloucestershire, in several veins. This fossil has been analysed by William Claysteld. See Contributions to Physical and Medical Knowledge, &c. collected by Dr. Beddoes.—Transl.

Its colour is a pale fky-blue. It occurs in flat layers, or firata, from  $\frac{1}{4}$ ,  $\frac{1}{2}$ , to  $\frac{5}{8}$  of an inch thick, included between two even fides; which last partly appear to be real seams, or joints (faalbänder), and, partly, are mere separating surfaces, formed by small clefts of the rock, filled with clay. On these exterior sides the sofiil has a dull appearance; but, internally, it is possessed of the ordinary lustre. It is easily comminuted, and consists throughout of coarse, parallel, brittle sibres, which form needle-shaped fragments.

The specific gravity of this soffil I sound to be 3,830. This considerable weight naturally suggested a doubt of its belonging to the species of gypsum. For this reason, it has been considered as a variety of ponderous spar, and placed in the mineralogical system in the character of shrous sulphat of barytes. This, however, is not more its proper place, than that of gypsum, or sulphat of lime.

### A

- a) Hundred grains of the fossil, finely pulverized, were boiled in one pound of distilled water; whereby it lost three grains. The water of the decoction was rendered turbid by mild alkalis, by oxalat of pot-ash, by the nitrated solution of silver; but, most of all, by muriated barytes.
- b) The powder, when again dried, was treated with muriatic acid; which, a trace of iron excepted, extracted nothing that was observable.

### B.

a) I ignited two hundred grains of fuch pieces of the fosfil as were pure, and free from the grey argillaceous matter,

matter, that croffes it in thin fiffures. It loft by this about one grain in weight; and the blueifh colour paffed into the light ifabella-yellow. It was next triturated, then mixed with 500 grains of carbonated pot-ash, and the mixture exposed in a filver pot to a moderate red-heat, during the space of three hours. The mass became grey, strongly coalesced, and nearly entered into-fusion. Upon this, I pulverized it, boiled it with water, and collected the earth upon the filter.

- b) The alkaline lixivium was super-saturated with muriatic acid, evaporated to drynefs, and the faline mafs foftened again with water, and neutralized with alkali. As by this treatment no feparation of earth was observable, I saturated again the lixivium to excess with muriatic acid, and combined it with muriated barytes. In this way I obtained 254 grains of barytic sulphat, which, upon ignition, weighed 250 grains.
- c) That earth, which remained after the decoction of the faline mass that had been fuled with the alkali (a), was combined with dilute muriatic acid, which readily attacked, and dissolved it entirely, with effervescence. Caustic ammoniac, added to the colourless solution, clarified by filtering, threw down the small portion of iron which it contained in scarcely perceptible brownish flocculi. The solution being thus freed from iron, I precipitated its earthy portion by carbonated ammoniac, affifted by heat.
- d) The earth hereby obtained was very white, tender, of a moderate gravity, and weighed 164 grains in its dry state. It was again dissolved in muriatic acid, and the folution made to crystallize by gentle evaporation. It gradually, and entirely, that into long needled cryftals of fix unequal furfaces; which middle, or earthy falt, proved, upon trial, to be mere muriat of strontian-earth. A little of this

falt, brought into contact with the wick of a burning candle, gave to the outer flame a highly beautiful carmine-red; and a folution of it in moderately strong spirit of wine burned with the same colour, when cotton, or printing paper, dipped into it, was set on sire.

Hence it appears, from this analysis, that the above fossil, with the exception of its trisling portion of iron, confists solely of sulphated strontian-earth.

C

I repeated this analysis in a shorter way: by boiling with alkaline lye, without previous ignition.

- a) One hundred grains of the fossil, ground to a most subtle powder, were mixed with a triple quantity of carbonated pot-ash, covered with six ounces of water, made to boil, and kept in that state during half an hour.
- b) The lixivium, filtered off from the remaining earth, was faturated to excels with muriatic acid, in which flate it continued clear; and was then combined with successive portions of muriated barytes, till no more precipitate enfued. The fulphat of barytes, thus produced, weighed 126 grains after washing and drying, and 124 after ignition.
- c) The earthy part of the fossil, which had been disengaged from the sulphuric acid by boiling with alkali, and had in its stead taken up carbonic acid, weighed 82 grains. Muriatic acid dissolved it entirely, and with rapidity, leaving only a few brown particles behind. The filtered solution was first treated with an over-proportion of caustic ammoniac, and, when no longer rendered turbid by it, was precipitated by mild, or carbonated pot-ash.—It gave again

# 398 XXXIX. Of Sulphated Strontianite, &c.

again its former weight of carbonated strontian-earth; namely, 82 grains, when dried in the air. When heated to redness, it formed a moderately conglutinated mass, and occupied only one half of its former volume; yet it did not lose an entire grain in weight. After trituration, though previously ignited, it dissolved rapidly, and with effervescence, in muriatic acid; and gave, by this combination, muriated strontian-earth, in long, thin columns, of fix unequal lateral surfaces.

Hence, the result of this decomposition in the humid way, accomplished so completely, and with so much ease, most exactly corresponded with that of the preceding.

Now, fince previous experiments have shewn, that 126 parts of barytic fulphat contain 42 of real fulphuric acid, or without water; and fince 82 parts of carbonated strontian-earth contain 58 of pure strontian-earth, the proportion of the ingredients constituting the Pensylvanian, blue, fibrous, sulphated strontianite is accordingly:

Strontian-earth .				1	58
Real Sulphuric acid			6		42
Oxyded iron, a flight	tra	ce			

100

By these analytical experiments it is fully proved, that I was not mistaken, when I suspected this sossil to be a sulphat of strontian-earth. In sorming that conjecture, I was chiefly determined by its specific gravity, which is considerably less than that of ponderous spar; and, likewise, by its sibrous texture: for, even the artificial combination of strontian-earth with sulphuric acid, effected by dissolving that earth in this acid, crystallizes into needles, resembling the sibres of the fossil, though smaller and more delicate.

# [ 399 ]

# XL. CHEMICAL EXAMINATION

OF THE

WATER OF THE BOILING SPRING, at RYKUM, in Iceland\*.

CONSIDERING the flowness, with which the knowledge of the chemical properties of even the most common natural bodies usually advances, it is not surprizing, that even those of filiceous earth have so long remained but partially investigated. This earth has always been considered as a substance, by itself, absolutely insoluble in water. It was, therefore, totally neglected in hydrologico-chemical inquiries, or researches into mineral waters, until Bergmann directed the attention of chemists to its solubility in simple water, and demonstrated that it exists in a state of solution in the Geyser, and other boiling springs of Iceland.

But although, in this instance, this celebrated philosopher justly considers the heat, which the water of those springs possesses when it rises into day, (and which even then is higher than that of ordinary boiling), as a means of promoting the solution, yet experience has shewn, that an actual solution of silex in water takes place, not only in springs, the natural temperature of which is much inferior to the ebullient heat of those in Iceland, but also in several other mineral waters: and even that some common sweetwater springs contain dissolved siliceous earth.

Thus, when I was attentive to this point, whilst analysing the mineral waters of Carlsbad\*, I found that 1000 cubic inches of the main spring contain 25 grains of filex, actually dissolved.

That,

<sup>\*</sup> Read in the Royal Academy of Sciences at Berlin, August 28, 1794.

# 400 XL. Water of the Ebullient Spring

That this is not the greatest quantity of siliceous earth soluble in water, and that, especially, the hot springs in Iceland might possily contain a much larger proportion of it, I was led to conjecture from the siliceous tusas which they deposit in considerable quantities. At that time, however, a proof of this opinion, supported by chemical investigation, was still wanting. It gave me, therefore, the greatest pleasure, when I received a sufficient quantity of water of one of the principal Icelandic springs, which enabled me to perform this inquiry, and to compare its result with that of the analysis of Carlsbad water.

In modern times, Uno von Troil, and after him, Banks and Solander, have particularly deferved well of the Natural History of Iceland, so remarkable in several of its individual subjects, some of which are unique in their kind. The latest voyage to that island, undertaken for the purposes of Natural History, is that of Stanley, in the year 1789. This learned traveller, (who has given in the papers of the Royal Society of Edinburgh a circumstantial description of the spring at the Geyser), when collecting the natural products of that spot, had likewise providently brought back with him a number of bottles filled with the water of those ebullient springs.—Two of these, that came to my hands, served for the following analysis.

The water contained in both bottles is from the spring at Rykum. From this spring, 24 English miles distant from Hasnistord, the water rushed formerly out to the height of 60 or 70 feet. But since the orifice of the spring has been covered, for the greatest part, by an overthrow of the rock, the stream of water, at present, spouts off sideways, from 50 to 60 feet. The heat of this spring, even after the jet,

<sup>\*</sup> See p. 274 of this work.

is still so intense, that Fahrenheit's thermometer rises to 212°. Therefore, as it is beyond a doubt, that part of the heat is lost during the spouting, and, consequently, that the water must have been some degrees hotter in its subterraneous reservoirs; Nature affords us here an instance, in the large way, of what Art performs in the small, by Papin's digester: namely, that confined water, even while in its unelastic, dense, liquid state, is capable of acquiring a degree of heat, surpassing that of its boiling point.

The water, in both bottles, was clear, bright, without fediment, and without tafte. Yet, at the spring itself, it shewed some sulphureous ingredient, according to Stanley. For, when employed fresh from the spring, it gave to the insussion of tea prepared with it, as well as to the meat boiled in it, a nauseous taste; whereas, the water from the spring at the Geyser, used in the same manner, gave no sign of it. But as, in the water which I examined, I could not discover any sulphur, either by the taste, by the smell, or by re-agents, it remains undecided: whether this effect proceeded from a portion of highly volatile, sulphurated, hydrogen gas, only observable at the spring itself, or whether, perhaps, the smell produced by putrescent, organic substances has not been mistaken for it; which last is not seldom the case, with various waters, supposed to be hepatic.

On employing other re-agents, it appeared, that this water from Rykum contains neither free carbonic acid, nor iron, nor lime, nor magnefia; and that carbonated, muriated, and fulphated soda, are to be expected.

Guided by these previous indications of the constituent parts of this water, I performed its analysis in the following manner.

1 ... t evaporated

I evaporated a hundred cubic inches of it in a gentle fandheat. When this quantity had been reduced to a remainder of about fix cubic inches, I found it coagulated to a palebrownish, stiff, somewhat turbid jelly. This evidently shewed, that this water had contained a considerable portion of dissolved filiceous earth, which now appeared in its usual gelatinous form. After the evaporation had been carried on to perfect dryness, the powder which was left weighed 25½ grains.

To feparate the filiceous earth from this refidue, previously to the subsequent operations, I poured water upon it, and when softened, I threw it upon the filter, washed the feparated earth, and exposed it to a moderate temperature, to dry. It appeared in a delicate, loose, pulverulent state, and weighed nine grains. To discover whether it was pure, or mixed with any other soluble earth, I digested it with muriatic acid; but when this was again filtered off, it contained nothing extraneous, except a trace of aluminous earth, hardly worth noticing.

Hence, the falts still held in solution, deducting the nine grains of silex, amounted to  $16\frac{1}{2}$  grains. Concentrated acetic acid was then dropped into the liquor to the over-saturation of the soda; and when the mixture had been evaporated to dryness, I separated, by highly rectified alkohol, the acetite of soda thus produced, and sound the weight of the residue, again desiccated, to be  $13\frac{1}{2}$  grains. From this it sollowed, that the ingredient, carbonat of soda, reckoned in its dry state, amounted to three grains; which are equal to eight grains of crystallized mild soda.

Those 13½ grains, which yet remained, were liquested in a little water, and the solution left to spontaneous evaporation. It gave crystals of muriated and sulphated soda. To find the proportion of these two salts to each other, I re-dissolved

re-diffolved the mixture in water, and decomposed it: first by acetated barytes, and then by nitrated filver. - Calculating afterwards the quantities of the precipitated sulphat of barytes, and muriat of silver, upon the basis of other comparative experiments, I found, that in those 13½ grains were contained 8½ grains of common salt, and sive grains of Glauber's salt, reckoned in its dry state, or 12 grains, if crystallized.

According to this, the above  $25\frac{1}{2}$  grains of falt, afforded by 100 cubic inches of water from the boiling spring at Rykum, when deprived of their water of crystallization, or in the desiccated state, consist of:

Garbonat of foda (natron) .		3 grs.
Sulphat of foda (Glauber's falt)		5
Muriat of soda (common falt)	. 4	8,50
Siliceous earth		9
	pingin	
		25 50

Shortly after the conclusion of the foregoing analysis, I found in the Annales de Chimie, Paris, 1793, that a similar examination had been made of the Icelandic hot springs, by Dr. Black of Edinburgh, together with a full detail of the method he pursued. In this inquiry, he likewise was supplied with the water by Mr. Stanley.

In order to compare the refults of the analysis of the spring-water at Rykum, made by Dr. Black, with mine, I reduced the constituent parts, enumerated by him, to the proportion of 100 cubic inches, equal to 29,000 grains of water. Hence, omitting unimportant fractions, they stand in the following proportion:

# 404 XL. Water of the Ebullient Spring

Carbonated free soda	. 1,50 grains
Silex	
Muriat of Soda	. 8,40
Dry fulphat of soda	. 3,70
printed that he thought of	24,40

When the numerous, and partly unavoidable causes are considered, which occasion small differences in the proportion of the constituent parts discovered, these two analyses may be considered, upon the whole, as reciprocally confirming each other. The quantity of alumine, which, being very trifling, I have not determined, should, according to Dr. Black's analysis, be estimated at  $\frac{1}{7}$  of a grain in 100 cubic inches of water.

What in particular has attracted the attention of Dr. Black is the filiceous earth he discovered, and its solution in water. For this reason he says, that in the course of that inquiry he had detected in silex such properties as have never before been suspected in it, or never been accurately described. He here principally alludes to the sact, that siliceous earth dissolved by sixed alkalis will not separate from them, even when neutralized by alkalis, as long as a sufficient quantity of water required to that effect is present \*.

Dr. Black asks; "How and by what means is the filiceous earth dissolved in water?—Is the hot water, of its own accord, possessed of the power of dissolving this

earth;

<sup>\*</sup> Without inculpating the ingenious Dr. Black for this little deficiency in his acquaintance with the experiments made by the German Chemists, I cannot avoid remarking, that I have, at an earlier period, known and described that property of siliceous earth. See my Chemische Untersuchung des Elassishen Steins aus Brasilien, im. 6. B. der Schrift. d. Berl. Gesellschaft Naturforsch. Freunde. 1785.

" earth; or can this be effected only by the means of the " intervening alkali?"-In answering these questions, he does not approve of Bergmann's opinion, that the folvent power of water, affisted by heat, is alone sufficient for this effect. He rather thinks, that the alkali is the efficient cause of this solution, and the heat merely a means of promoting it. In his opinion, a chemical combination of the filex with alkali is always prefent, when water exerts a diffolving power on the earth, and this idea he supports by the example of the agency of hot aqueous vapours upon glass. The doubt, which might be raised against it, from the disproportion of these two substances to each other in the Iceandic hot springs, he wishes to obviate by stating, that the filex had originally been united in them with a much larger portion of alkali; but that, subsequently to the folution of this compound in water, part of the alkali had again been neutralized by acids, or acid vapours, that combined with the fluid. But there is no necessity for this mode of explanation; as it is manifest by several facts, that filiceous earth alone, if under favourable circumstances, is foluble in water, without the concomitant aid of alkaline falt.

Moreover, this opinion, that the filex exists in the above mentioned springs in a state of chemical solution by foda, feems likewife to have led Dr. Black to presuppose this alkali in those waters in the caustic or pure state, that is, free from carbonic acid; because it is allowed on all hands, that, in this state only, is it capble of effecting this folution. Yet, not to mention that no proof is given of this hyphothesis, there occurs no instance in nature, upon which to establish its probability. The very effervescence, that enfued on faturating with acetic acid the faline refidue left by the evaporated water, would prove the contrary; unless, indeed, it be objected to this argument, that the alkali had attracted the carbonic acid, during the eva-XLI. poration of the water. D d.3

### XLI.

### CHEMICAL EXAMINATION

OF THE

SILICEOUS TUFA, (Kieseltuff.)

From the Geyser.

IN the same manner, as mineral waters impregnated with lime deposit the calcareous tufa in various forms, do the hot springs in Iceland deposit their siliceous ingredient in the form of tufa. It is likewise of this filiceous tufa that the wonderful pipe and bason consist, which the Geyser, the largest of the springs in Iceland, has formed for itself. Von Troil found, in the year 1772, the circular orifice of that pipe, whose depth is unknown, and which the ignorant Icelander confiders as the gate of hell, to be 19 feet in diameter. On the upper part, the aperture widens in the form of a large bason of 60 feet in diameter, and whose exterior border is 9 feet higher than the pipe itself. From this pipe the water spouts out several times in the day, by gushes, at unequal intervals of time, with powerful force, and fometimes to the height of above 100 feet. What a grand fight must it afford, to see a column of boiling water, 19 feet in diameter, rush up to such a height! To form an idea of that column of water, let it be compared with the most celebrated artificial fountains, for example, that on the Carlsberg near Cassel in Hessia, which is only 14 inches in diameter, and hence is more than 16. times smaller than the Geyser.

As the filiceous tufa produced by this spring is to be met with only in few collections; and as,—besides the short account given by Bergmann, in his treatise De Productis Volcanicis,—no other characteristic description of it exists, I here insert that, which Karsten has drawn from the specimens in my possession.

# SILICEOUS TUFA.

"Its colour is partly reddish-white, and externally speckled with cochineal-red; partly greyish-white, with yelloish-grey stripes.

"It occurs in massive lumps, and also denticulated, co"roded, and most finely botryoidal.

"Its exterior surface perfectly-dull.

"But internally partly dull, in part highly glittering, and then of a filky lustre; here and there a little resplendent.

"Its fracture partly compact, and totally flat conchoidal, or uneven; partly fibrous.

"It breaks into indeterminate angular, not very fharp fragments.

"It confifts, when conchoidal, of finely grained infulated pieces; when of uneven fracture, it then is found in feparate thin and curved testaceous pieces; and its fibrous varieties present no detached pieces.

"It is also, more or less, strongly transparent on the stedges."

"Semi-indurated; may be fplit in pieces without any great difficulty; is very brittle, and of little weight."

Note. The fibrous variety has always the lustre of filk, and the fibres cross each other in such a manner, that its inside has a cellular appearance.

For the following analysis of the filiceous tufa from Iceland, I have chosen the fibrous variety, whose specific gravity is = 1,807.

One hundred grains of it were finely triturated, and ignited for two hours, in a filver crucible, with four times its weight of mild pot-ash. When the concreted mass had cooled, I poured water upon it, saturated it to excess with muriatic acid, and siltered it after some digestion; upon which the siliceous earth remained behind in its usual slimy form.

The acid fluid, being afterwards faturated with mild, or carbonated pot-ash, was rendered turbid by it; and deposited a slight loose precipitate; which, collected, washed, and desiccated, weighed 3 grains; but when re-dissolved asresh in muriatic acid, it still left I grain of silex.

The folution still contained 2 grains of dissolved matter: namely,  $\frac{1}{2}$  grain of exyded iron, and  $1\frac{1}{2}$  grain of aluminous earth. These, likewise, were separated.

Hence the ingredients, found in the above 100 grains of analysed fibrous filiceous tufa, from the Geyser, confissed of:

Silex	d bods	deta	90
		1	1,50
Oxyd of iron	and the	10	0,50
3/2			100

e Krmisin Jurated

### XLII.

# CHEMICAL EXAMINATION

OF THE

# ELASTIC QUARZ\*,

(Sand-sbiefer, flexible Sand-stone)

From Brafil.

THE fingular elastic flexibility so seldom occurring in the mineral kingdom, in which this sossil, in its form and appearance, resembles novaculite (Turkey-hone), has attracted the attention of Naturalists, but at the same time has led many persons to doubt its existence as a natural substance, and to suspect, that this may probably be a product of art. It comes from Brasil, near Villa-rica, the principal town of the province of Minas Geraës, which sact was, for a while, kept a secret. There it occurs in not very thick strata, whose hanging and spading sides are cased over by a grey crust of  $\frac{1}{4}$  inch thick; and from thence it was brought

<sup>\*</sup> Schriften der Berliner Gesellschaft Natursorschender Freunde.
6. B. 1785, pag. 322.—The miners indicate by these expressions the greater or less slope in the strata, though chiefly with reference to rake-veins, not fully perpendicular. The hanging side is that towards the day, and is also called hanger; and the hading side, which likewise goes by the name ledger, is the under one next to the bed of the stratum. See Williams's Natural History of the Mineral Kingdom, 8vo. Edinb. 1789. vol. I. page 269.—Trans.

to Portugal the first time, in the year 1780, by the Marquis de Lavradio, Viceroy at Rio de Janeiro. Among the specimens I have seen, that of the Imperial Cabinet at Vienna, so remarkable for its precious sossils, is by sar the greatest; it being 26 Vienna inches long, 16 inches broad, and I inch thick. It is, however, probable that this stone, together with its remarkable physical property mentioned before, was already known in the sixteenth century; and that it is the same with that described by Gassensian Vita Peireskii in the character of a stexible wetstone (novaculite); as suggested by the authors of the Göttingische Gelehrte Anzeigen, when this stone has again been brought into notice †.

### A

On infpecting with a microscope the homogeneous or integrant parts of which this elastic stone is aggregated, and which may be easily separated by compressure or levigation, I sound them all alike: that is, they were all stat, longish plates or scales, perfectly clear and pellucid. All their difference consisted in the variety of their outlines; some truncated more sharply; others more obtusely; others longer, but very thin; while others were broader and shorter; but most of them I perceived on one or both sides notably sinuated. I am inclined to think, that the elasticity of this sossil originates solely from the form of its aggregation. For, as may be distinctly seen at the first glance in the entire stone, all those longish lamellæ are interwoven

Dibr. IV. ad annum 1630. pag. 254. Edit. 1706.

<sup>\*</sup> Of the year 1784. Number 211.

in one fingle direction, and implicated in fuch a manner, that each junction refembles a vertebra, or hinge. With this idea also corresponds the particular kind of the flexibility of the stone, which is not tough or coriaceous. For, if the stone be held upright and shaken, it vibrates with some noise to and fro; but as soon as its agitation is discontinued, its parts conjoin again strmly by a force like a spring.

B.

I now proceed to its chemical analysis,

a) As, on triturating, I found the particles of the stone extremely hard, which was indeed previously ascertained by its faculty of cutting glass with ease, and of striking fire with steel, I endeavoured to facilitate its decomposition by previous mechanical comminution.

To effect this, I subjected one hundred grains to red-heat, and quenched them in cold water; but I observed, that by this neither their weight nor their hardness had decreased. They were then reduced to an impalpable powder in an agate mortar, mixed with four parts of dried carbonated soda, and ignited under the mussle in a porcelain-saucer, during six hours, in a moderate degree of heat; by which the mixture only conglutinated, without actual sussion. The ignited mass was pulverized with water, super-saturated with muriatic acid, digested and filtered. A quantity of very loose siliceous earth, to the weight of 96½ grains, remained on the filter.

b) The separated muriatic sluid was treated with Prussian alkali; and the blue precipitate, thence arising, ignited.

## 412 XLII. Examination of Elaftic Quarz.

It weighed one grain; of which, however, only  $\frac{1}{2}$  grain can be reckoned as oxyd of iron, entering into the 100 grains of the decomposed fossil.

c) At last, by saturating the solution with carbonated potash, a tender earth was thrown down; which, after washing, drying, and ignition, weighed 2½ grains; and, examined by means of sulphuric acid, was found to be aluminous earth.

Consequently, hundred parts of elastic quarz from Brasil have yielded:

Silex	1.0	96,50
Alumine	W.	2,50
Oxyd of iron .	ala (t)	0,50
id. eMbuailing, o	t let	99,50

There are fometimes very small blackish grains, like points, mingled with this stone. As these probably are garnets, or crystals of horn-blende, it seems that the portion of iron and alumine discovered in the fossil chiefly proceeds from them.

in a moderate degree of both; by which the misk-

#### colstill X parer tra

#### CHEMICAL EXAMINATION

OF THE

# GLASS-STONE (Hyalite),

From Dauphiny\*.

As the term Shörl was formerly used in too vague a sense; to remedy this uncertainty, it has been sound necessary to confine its mineralogical signification within narrower limits. On this consideration, the soffil here treated of, which Romé de l'Isle has sirst introduced into public notice, by the name, Schörl transparent, lenticulaire, but which has since become more known by that of Violet-Schörl, could no longer be ranked under that head. Werner, therefore, has classed it as a distinct species, and given it the name, Thumerstone. But it also has got other names, such as, Glass-stone, or Haylite, Pseudo-shörl, Glass-shörl, Oisannite.

It was, for the first time, discovered in Dauphiny, chiefly at Bourg a Oisans near Allemont; partly upon a blackish-grey horn-blende-state, partly in the clefts of a greenish-grey gneis, already somewhat softened by decay, where it is accompanied by quarz, amianth, and crystallized actinolite. Most of its crystals are upright, and their leading figure is very compressed rhomboidal parallelopipedons or

<sup>\*</sup> See Magazin für Die Naturkunde Helvetiens. I. B. 1787 pag. 180.

flat rhomboidal tables, sharply truncated, and of a fine striated surface. The colour of the purer translucid crystals is a faint amethystine-red, which in the less bright crystals changes to the white-grey.

Glass-stone, or hyalite, is also found in the Pyrenees at Barèges, and other places; but not in such clear and large crystals as that of Dauphiny.

The third place where this fossil occurs is the mine Niklas, at Thum, near Ehrenfriesderdorf in Saxony; where it is rarely met with in a crystallized state, but mostly in separate, massive, testaceous pieces.

Besides these, I have likewise found it in a specimen of native silver, from Kongsherg, preserved in the instructive collection of Mr. Siegsried at Berlin.

a) Glass-stone, treated upon charcoal before the blow-pipe, foams much as foon as it becomes red-hot, and readily melts into a black, shining, opake bead. This phenomenon, along with the great difference of its external characters, affords a sufficient ground to separate the byalite from shorts, with which it has been consounded. The true shorts, indeed, likewise sufe upon charcoal; however, sirst, their susion is not accompanied by a brisk effervescence, but rather by a languid swelling; secondly, a much stronger and more lasting heat is required, to make pure shorts run into a globule equally sused in all its parts; and, thirdly,

<sup>†</sup> Fuller descriptions of its external characters are found in the later mineralogical elementary books, among which descriptions, that given by Esner is the most complete. See his Mineralogy. II. B. I. Abth. S. 258.

most species of shorts, if not all, lose their colour by the fire; whereas the clearest and least coloured fragments of that fossil yield a completely black vitreous bead. In this respect, hyalite agrees more with horn-blende \*.

- b) To discover the constituent parts of hyalite, I chose that from Dauphiny, first mentioned. One hundred and fixty grains of the purest crystals, broken off from several druses (regular crystalline groupes), were ignited for one hour in a porcelain-pot, at a degree of heat not intense enough to suffer them. Their weight, colour, figure, and hardness, continued unimpaired. Only three grains were lost during trituration.
- c) These 157 grains of the pulverized stone, mixed with three times their weight of exficcated foda, were exposed for three hours to a gentle red-heat, in a procelain pot. After cooling, they were found conglutinated into a blueishgrey, compact, hard, finely porous mass, readily separable from the fides of the vessel. When finely ground, covered with water, and super-saturated with muriatic acid, the mixture acquired a gelatinous confistence, and a dirty brown colour. On diluting it with more water, and digefting it. oxygenated muriatic acid gas was extricated, and the brown colour disappeared; the fluid, superincumbent on the undisfolved, white, flimy earth, being clear and of a gold-yellow. This earth, after decanting the liquor, was digested anew with muriatic acid; then separated by filtration, washed, and Arongly ignited. It weighed 79 grains, and was filiceous earth.
- d) To obtain first of all the metallic part of the solution, I gradually dropped Prussian alkali into it, as long as any

<sup>\*</sup> On the habitudes of this fossil in porcelain-fire, see Essay I. No. 36.

precipitation would ensue. The deep-blue precipitate, thus procured, weighed  $61\frac{\pi}{2}$  grains, upon washing and drying; but, when strongly ignited, there remained only 28 grains, which consisted of black exyd of iron, obeying the magnet. From these must be subtracted the portion of iron retained by the salt employed; and hence, (from the result of another essay, made on purpose with a portion of Prussian alkali of the same preparation) only 15 grains of that metal are left to be put in the account as a constituent part of the sossil.

- e) The amethyftine red colour of the rough cryftals, and the blueish colour of the mass sused with soda, but still more the vapours of oxygenated muriatic acid emitted during the solution, shewed that manganese, as well as iron, was present in this instance. For this reason, I ignited those 28 grains of oxyded iron (d), adding 10 drachms of nitre; and when this last had been for a while in red sussion, I poured it off from the iron that lay at the bottom of the crucible upon a marble slab. When sixed again, the nitre appeared of an emerald-green. Thrown into water, it soon dissolved, tinging the liquid of an amethystine-red; and, when this colour had vanished, manganese fell down in light-brown, loose slakes, weighing 1½ grain. But, on being farther tried, it was sound to be still mixed with iron.
- f) I next began to examine the diffolved earths.—By the perfect and ready fusion of hyalite alone, and without addition, I was induced to suspect in it a considerable proportion of calcareous earth; but neither oxalic acid alone, nor oxalat of pot-ash, produced any turbidness or precipitate. However, as the sequel has shewn, lime was, nevertheless, present. This sact may serve as a caution, that even the very best re-agents ought not to be always trusted to with unlimited considence.

Carbonated

Carbonated pot-ash was now employed to precipitate the earth contained in the solution. It fell down, white, and of a loose form; and weighed 91 grains after washing and desiccation in a low heat. The fluid filtered off, together with the washings, were entirely evaporated, and the remaining dry saline mass re-dissolved with a little water. By this management 1½ grain of a granular earth was still left, which I edded to the preceding 91.

- g) Upon these 921 grains of earth I affused one ounce and a half of distilled vinegar, concentrated by freezing, leaving the whole standing for 12 hours. A feeble, but lasting effervescence took place. The acetic solution being decanted, another fresh ounce of acetic acid was affused upon the sediment; and, after 12 hours, it was exposed to a moderate temperature. When, after 48 hours, the subtle earth, which gave the folution an opaline appearance, had fubfided, I collected it upon the filter; washed, dried, and ignited it. It weighed then 411 grains. At this time the acetic folution yielded a white precipitate, by uncombined as well as by neutralized oxalic acid. But, as from this alone no certain conclusion could be made as to the presence of lime, I added to that fluid fuccessive portions of fulphuric acid, till the white granular precipitate ceased to fall down. The mixture, a little evaporated and filtered, left fulphat of lime behind, which, after ignition, weighed 38 grains.
- b) The liquor, filtered off from this last, was combined with caustic ammoniac. Aluminous earth fell down, weighing  $2\frac{\pi}{2}$  grains when ignited. The remainder of the solution afforded still some selenite, on evaporation to dryness; which, ignited, less two grains, and was added to the preceding 38 grains (g).

- i) In order to decompose the selenite, I boiled it during a quarter of an hour with a solution of carbonated pot-ash, in such a proportion as made the alkali predominate. The earth lest behind weighed  $26\frac{1}{2}$  grains, after washing and torresaction; and proved, upon trial, to be a highly pure carbonat of lime. Therefore, since nine parts of crude calcareous earth afford by ignition sive parts of burnt or quick-lime, the above-mentioned  $26\frac{1}{2}$  grains are equal to  $14\frac{3}{4}$  grains of calcareous earth, freed from water and carbonic acid.
- k) Those  $41\frac{1}{2}$  grains of earth (g), together with the  $2\frac{1}{2}$  grains (b), which I took for alumine, were combined with three drachms of concentrated sulphuric acid, and then diluted with some water. The mixture exhibited a pleasing rose-colour; but which, on inspissating the sluid almost to dryness, passed into a light blue: shewing thus the presence of a small trace of manganese. On being re-dissolved in water, it yet deposited some siliceous earth, weighing  $3\frac{3}{4}$  grains, after ignition. By subtracting these from the foregoing 44 grains, that were held in solution by the sulphuric acid here employed, the quantity of aluminous earth sound in the solid is reduced to  $40\frac{1}{4}$  grains.
- 1) To be affured that this ingredient is pure alumine, unaccompanied by magnefia, I heated the folution to the degree of boiling, and gradually faturated it with elutriated chalk, until it effervesced no more, and no acid could be observed to predominate. After gentle boiling for half an hour, I filtered the fluid, reduced its quantity by evaporation, and separated the selenite which yet appeared. However, no sign of sulphated magnesia could be perceived in the solution, either by the taste or by re-agents.

Thus the decomposed 157 grains of hyalite, from Dauphany, have yielded:

Silex	3345	82,75 40,25 14,75
that of manganese d)		15
The second second		
	and the same of the same	152,75
	Loss	4,25
	Carry star and a	The state of
management and the second	1	57

Wherefore, an hundred parts contain:

	97.3
Oxyd of iron and manganese	9,6
Lime ,	9,4
Alumine	25,6
Silex	52,7

[ 420 ]

XLIV.

### CHEMICAL EXAMINATION

OF

### CHRYSOPRASE,

And its concomitant Green Earth \*.

CHRYSOPRASE is a natural product, hitherto exclufively of Silesia, chiefly found near the village Kosemütz, in the Principality of Münsterberg; where it occurs in the clefts and disjunctions of a soft serpentine rock, together with quarz, hornstone, chalcedony, opal, asbest, talc, (magnesia) and various other species of earths +.

Authors are not agreed in stating the constituent parts of chrysoprase. Their opinions chiefly differ with respect to the principle that produces the green colour of this stone: some ascribing it to iron, others to cobalt, and some again to copper.

### FIRST SECTION.

## Analysis of Chrysoprase.

a) Some felected, pure pieces of chrysoprase were heated to redness, and quenched in water. Their colour was

hereby

<sup>\*</sup> See Beob. u. Entd. a. d. Naturkunde, 2 B. 2 St. Berlin. 1788.

<sup>†</sup> A more circumstantial account of the natural history and bed of chrysoprase, and the stones that accompany it, is given in Lehmann's Physisch-chemischen Schriften—and Gerhard's Beyträgen zur Chemie, and Geschichte des Mineralreichs; as also in his Grundriss des Mineralsystems.

Three hundred grains of this powder, mixed with twice their weight of dry carbonated foda, were subjected to a low red-heat for some hours, in a vessel made of porcelainclay. The mass was then powdered while yet warm, and digested with water. The solution acquired a dirty brownish colour, and left, upon filtration, a grey-yellow residue of 44 grains when edulcorated and dried. It passed colourless through the filter, and by saturation with muriatic acid, it yielded a copious precipitate; which, collected, washed, dried, and ignited, consisted of 268½ grains of siliceous earth.

- b) Upon the 44 grains of residue, that were separated on dissolving the ignited mass in water (a), introduced into a retort, I poured eight times their weight of nitro-muriatic acid, and digested them together. This done, I abstracted the greatest part of the acid, and what had distilled over I returned upon the contents of the retort; digested it once more, and then filtered the whole. There remained on the paper a white, loose siliceous earth, weighing 20<sup>1</sup>/<sub>4</sub> grains upon ignition.
- c) To the filtered folution I added caustic ammoniac in excess. Its colour, which before was of a dilute green, turned blueish; and a little brownish matter fell down in the form of slime. Upon this precipitate nitric acid was affused in a small retort, and again distilled off from it. This affussion and abstraction were repeated twice more; and, at last, the retort was strongly heated to redness upon charcoal. The residue I then dissolved in weakened nitric acid. A brown oxyd of iron remained, amounting to \frac{1}{2}

EE 3

grain, which, diffolved in muriatic acid, afforded, with Pruffian alkali, a deep blue; and, with tincture of galls, an ink-black precipitate. Whence this portion of iron, as it is fo fmall, can have no fhare in producing the green colour of chryfoprafe.

From the nitric folution, cleared from iron, carbonated ammoniac precipitated ½ grain of loose aluminaus earth, weighed in the dry state; but for which, in the ignited state, only ½ grain can be reckoned.

No trace appeared of magnefian earth.

422

- d) The folution, super-satuated with caustic ammoniac (e), was tried for lime; and with this view combined with carbonated soda. The precipitate produced was carbonat of lime. Upon desiccation, it weighed 4½ grains, which denote 2½ grains of calcareous earth, in the ignited state.
- e) The fluid, from which this lime had been feparated, fill preferved its blueish colour (c), and yielded no precipitate, either with acids or with alkalis. For this reason, it was distilled to dryness. There remained in the retort a yellowish saline mass, which again made a green solution with water. When this solution had been combined with mild pot-ash, it deposited only a slight portion of a white-greenish earth; the remainder would not precipitate, not-withstanding all my endeavours: therefore, I dropped into the mixture as much nitric acid as was necessary to re-dissolve the precipitate, and treated it with prussiat of pot-ash, until the whole was separated. The collected, washed, and dried precipitate had a sea-green colour, and weighed 17 grains.

f) In this precipitate, therefore, that constituent part of chrysoprase was contained, on which its green colour depends.

pends.—What then is this constituent part? Certainly not iron; for this, by its nature, will never diffolve in caustic ammoniac, nor ever produce with it a blue colour. Besides, it would have been precipitated of a deep blue, by the Pruffian alkali, with which it was tried (c); and, lastly, the oxyd of iron, of which there exists only a very slight pertion in the chrysoprase, had already before been separated (c). Neither can it be faid, that copper forms any part of that precipitate. This metal does indeed dissolve of a blue colour, in ammoniac, as does the above-mentioned precipitate; but as this property does not exclusively belong to copper alone, no decifive conclusion can be deduced merely from this circumstance. Moreover, the bright aqua-marine colour of this precipitate, produced by means of pruffiated pot-ash, has absolutely nothing in common with the redbrown colour, with which copper always prefents itself, when thrown down from any folvent by that precipitant.

But the most convincing proof of the total absence of copper in this instance was afforded by the following experiment: I exposed the 17 grains of the greenish precipitate (e) to red-heat, in a crucible, and subjected the black-brown residue, which weighed seven grains, to vigorous digestion in nitric acid. By this treatment, a slight quantity of iron, originating from the Prussian alkali employed for the precipitation, was deposited; and all the remainder afforded a green solution with nitric acid. This I distributed into two phials; putting into the one a piece of polished iron, and into the other a stick of zinc. But in neither of them, both in the cold or heated, could the least indication of copper be observed.

g) After I was thus fully certain that no copper was present, I could not account for this constituent part of chrysoprase, otherwise than by taking it for axyded nickel.

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This

### 424 XLIV. Examination of Chrysoprase,

This conclusion was corroborated by all the phenomena above-mentioned, which wholly refembled those of other experiments which I made, by way of trial, with an oxyd, prepared from the utmost pure reguline nickel.

Being accustomed to repeat those experiments, which lead to new discoveries, in order to secure myself, by the agreement of the results, against accidental mistakes, I subjected another quantity of chrysoprase to analysis.

The blue folution of exyd of nickel in ammoniac, which I then obtained, I distilled to dryness from a retort; after which, I roasted the residue with wax, in a gentle heat, and tried to reduce it to the reguline state upon charcoal, by means of borax and susible phosphoric salt. The reduction succeeded with either flux; but it required to be strongly assisted by the blow-pipe. While reducing with borax, the metal would not easily run into a button; but, with the phosphoric salt, it proved somewhat more susible, and yielded a white-grey bead, that exhibited a shining polyhedral surface, and a finely grained fracture.

These metallic buttons were too sew to admit of a farther examination. For this reason, I endeavoured to procure more of them, which I effected by decomposing the green earth of chrysoprase, described in the following section; and the third section will shew, that those seven grains of the precipitate obtained by Prussian alkali, and ignited (f), denote  $2\frac{1}{3}$  grains of metallic nickel; or three grains of pure oxyd of nickel, when heated to redness.

Whence the constituent parts, produced from the 300 grains of chrysoprase decomposed, are:

Silex a) $268_{\frac{1}{4}}$ b) $20_{\frac{1}{4}}$ .	288,50 grs			
Alumine c)	0,25			
Lime d)	2,50			
Oxyd of iron c)	0,25			
Oxyd of nickel . g)	3			
engling have be recovered to an every larger Recovered the Acquirible and the second	294,50			
Lofs, which the chrysoprase suffers by				
ignition, and chiefly confifts of par-				
ticles of water	5,50			
in a colony we are style and such that	-			
	300			

With this proportion of the conftituent parts of chryfoprase, the results of several of my experiments agree pretty well. Yet I readily admit, that, on repeating fuch experiments, fome small differences may take place, especially in the portions of iron and nickel, fince the green colour of this fosfil so often varies. In like manner, I have sometimes discovered more sensible indications of magnesian earth, though never amounting to more than \( \frac{1}{8} \) per cent.

### SECOND SECTION.

## Analysis of the Green Earth of Chrysoprase.

a) Among the varieties of the glittering, fattish, green earth, that fometimes accompanies chrysoprase, I selected that for the prefent enquiry, which by its uniform applegreen colour is diffinguished from the others, as the most pure and least contaminated with heterogeneous matters. Upon three hundred grains of this, put in a retort, I poured four times their weight of an aqua regia, composed of three parts of muriatic, and one of nitric acid, and at first di-

gefted

gested them for a while. The action of the acid upon the earth was attended with an extrication of yellowish vapours. That portion of the acid which passed over was poured back into the retort, with the addition of one part of fresh nitric acid; and, after a second digestion, distilled off to moderate dryness. The remaining mass, whose green colour was now changed into a yellow, was again digested with the acid that had been abstracted, and next separated by filtering from the indissolvable residue.

- b) This refidue, which refisted the attack of the digesting acid, confisted of a very tender, loose, dazzling-white, and glittering siliceous earth, that weighed 105 grains after deficcation in a red-heat. I mingled and ignited it with 210 grains of carbonated pot-ash; upon which I triturated the mass with water, super-saturated it with nitric acid, digested and filtered it. In the said that passed through the paper nothing could be found, except one grain of silex.
- c) The folution, separated from the filex (a), had a green colour. It was combined with carbonat of pot-ash, and the precipitate produced was edulcorated and dried in the air. This precipitate had a pale green colour, like the crude earth, and weighed 280 grains. By way of previous examination, I dissolved one fifth part of it in muriatic acid, and tried the solution, which again exhibited its original green colour, in the following manner:
  - a) Ammoniac threw down a white green precipitate, which, on adding more ammoniac, in part re-diffolved, and produced a blue tincture.
  - β) By means of pruffiated pot-ash, a copious feagreen precipitate, inclining to blue, fell down.

- y) Tineture of nut-galls produced a faint ink-colour.
- 3) With alkaline fulphuret there arose a blackish precipitate.
- i) In the remainder of that fifth part of the muriatic folution I immerfed a polished iron, which became tarnished, of a grey colour; but no fign of copper, either in a cold or a warm temperature, appeared.
- d) The other four-fifth parts of the green precipitate (c), which now contained one half ounce of rough earth of chrysoprase, cleared from filex, were dissolved in nitric acid, and treated with an over-proportion of carbonated ammoniac, shaking it several times. The supernatant blue solution was decanted on the next day from the residue; and to this last fresh portions of ammoniac were repeatedly added, till it ceased to afford a blue tincture, that could be observed.
- e) The residue, left after the extraction by ammoniac, was a loose white-grey earth, weighing 85 grains when dried in the air. It was dissolved by digestion in nitromuriatic acid, and treated with caustic ammoniac, until nothing more fell down. The light-brown precipitate then obtained was heated to redness; after which it weighed 26 grains. Nitric acid was next affused upon it in a retort, and again abstracted by dissillation; and this abstraction and digestion were repeated twice more. I then urged the fire of the coals so as to redden the retort, powdered the calcined residue, dissolved it in dilute nitric acid, and threw it upon the filter. There remained a red oxyd of iron, which, dried and deslagrated with wax, was attracted by the magnet, and weighed eleven grains.

## 428 XLIV. Examination of Chrysoprase,

- f) The 15 grains which yet remained in the folution after the separation of these 11 grains of iron (e), were precipitated by mild soda, desiccated in the air, and extracted in the cold by distilled vinegar. This attacked it with effervescence; but, when again filtered off, and treated with carbonated soda, it deposited, without any effervescence, a loose earth, which after ignition weighed three grains; and, being tried with sulphuric acid, proved to be magnesia. The remaining earth, now reduced to 12 grains, when calculated the ignited state, was alumine.
- g) There still remained that sluid (e), from which the iron, and the magnesian and aluminous earths were precipitated by caustic ammoniac. It was warmed, and combined with carbonat of soda, which precipitated 1½ grain of crude calcareous earth, for which, to avoid small fractional parts, I put one grain of burnt lime in the account.
- b) I now return to the blue extraction, prepared with carbonated ammoniac (d). I distilled it, together with the water employed for lixiviating the residue, from a retort, almost to dryness. The residue I softened with water, and found, that, upon filtration, it lest seven grains of a pulverulent isabella-coloured earth; which, by ignition, lost one half of its weight, yet continued unchanged in colour.—When previously dissolved in nitric acid, it was thrown down of a white-yellow by alkalis, of a pale olive by prussiated pot-ash, and of a light-brown by arsenical alkaline sulphuret; but by the tincture of galls it would not at all precipitate. On this account I considered it as an impure oxyd of nickel.
- i) As no ammoniac any longer predominated in the fluid which had been filtered off from the isabella-coloured earth (b), it had again a bright grass-green colour. I now endeavoured

endeavoured to separate the substance which it held in solution, by adding alkaline salts.—Yet I could not completely succeed; and, notwithstanding that I watched the most exact point of saturation, this middle (or earthy) saline liquor still retained part of that substance in a dissolved state. The greatest portion of the precipitate I first obtained by means of mild ammoniac; and when this had been separated, mild pot-ash threw down another portion. The precipitate, collected, washed, and dried in the air, had a pale, whitish-green colour, and weighed 50 grains.

- k) Thirty grains of this precipitate were ignited for  $\frac{1}{2}$  an hour; whereby its whitish green was altered to a greygreen: and it lost half of its weight. Those 50 grains, therefore, must be estimated at 25 grains of ignited oxyd of nickel. In this instance I did not perceive that fort of excrescence which usually takes place when oxyds of nickel, procured from ores of that metal, are exposed to fire; perhaps, because no portion of arsenic, by the escape of which those delicate ramifications are probably produced, was here present.
- 1) Since neither acids nor alkalis would precipitate any thing from the remainder of the fluid above mentioned (i), it now only remained to apply pruffiat of pot-ash. This still precipitated a considerable quantity of a pale sea-green earth; which, upon washing and ignition, became granular, assumed a brown colour, and weighed 21 grains. This quantity, calculated after the manner to be explained in the third section, indicates 9 grains of ignited, pure oxyd of nickel.

Therefore, the constituent parts contained in half an sunce of that variety of the green-earth of chrysoprase, which

## 430 XLIV. Examination of Chrysoprase,

had been employed for this investigation, are the following:

Silex (fince 105 grains were)	gain gar			
obtained from 300 b)	. 84 grains			
grains of that earth)	and the second			
Alumine f)	. 12			
Magnefia f)	3			
Lime g)	I			
Oxyd of iron e)	. II			
Oxyd of nickel b) $3\frac{1}{2}$	trans-			
· · · · · · k) 25 }	. 37,50			
ating a chimage has along acquire or an	148,50			
Lofs, very nearly approaching that]				
which the rough earth of chryso- \	. 91,50			
prase suffers by red-heat	Service of the second			
Company to supercompany seed to the village for the	240			

### THIRD SECTION.

Closer Examination of the Portion of Nickel contained in Chrysoprase, and its concomitant Green-earth.

In order to examine more accurately the whitish-green metallic oxyd that enters into chrysoprase, as well as its concomitant green earth, I procured another quantity of it, by repeated decompositions of those two substances, performed in the manner before described. This I subjected to the following experiments.

a) Treated with ammoniac, it foon dissolved, and yielded a pure blue tincture, though less saturated than that which is

afforded by the folution of copper in ammoniac, made with the fame proportion of these respective ingredients. If nitric acid be affused in a quantity a little beyond what is necessary to saturate the ammoniac, the solution appears of a light grass green.

- b) It entirely diffolved, and with effervescence, in fulphuric acid. It likewise gave with this a green solution; from which
  - a) Carbonated pot-ash precipitated that oxyd of a whitish-green.
  - β) Pruffian alkali of the fame, but fomewhat darker colour.
  - y) Tincture of galls produced no change nor turbidness in the folution.
  - d) Arfeniated alkaline fulphuret threw down a great quantity of a black-brown precipitate; but of which
  - s) Neither on polifhed iron, nor on zinc, any thing of a metallic nature would deposit; the solution producing only some weak, grey spots on these metals.
  - ζ) By exposure to open air, this solution shot into clear, emerald-green, rhomboidal crystals of sulphated nickel, which, by roasting, crumbled into a white-greenish powder.
- c) The green oxyd of nickel, tried upon charcoal, with a blow pipe, shewed the following appearances:
  - a) Ignited by itself, it became violet; but shewed no disposition to suse.

8) With

## 432 XLIV. Examination of Chrysoprafe,

- β) With borax, affifted by a continued stream of air from the blow-pipe, it fused, and was partially reduced to a white-grey metallic mass; but which would not run into one single button.
- y) Phosphated alkali likewise reduced it to the reguline state, at the same time that it more readily united into one bead. The glass globule exhibited, during the action of heat, a garnet-red, but, after refrigeration, a hyacinthine colour.
- d) I now attempted its reduction in the crucible. With this defign, I introduced the 15 grains of metallic oxyd, remaining after ignition from those 30 grains mentioned (2 Sect. k), into a crucible, previously mixed with the same quantity of refin, and three times that of calcined borax, and covered the whole with common falt. The veffel was then conveyed to the melting-furnace, and the fire managed in about the fame manner as on affaying copper. After cooling, the infide of the crucible was found lined with a thin glazing, on fome places of the upper part, of a green, but on the lower one, of a bright hyacinthine colour. The mass itself fused well; and, on breaking the veffel, there was found, under the colourless faline cover, a transparent light-brown glass, and, between this, a metallic button. This, however, being refractory, had not run into a compact mass, but was only conglutinated, confifting of feparate, small, loosely-coherent globules.

This metal had a perfect metallic lustre, and a grey colour, verging to the red When freed by elutriation from the adhering scoria, it weighed 9½ grains. But as here and there some minute grains were sticking to the fragments of the crucible, not easily separable, I may properly

perly estimate them at  $\frac{1}{4}$  grain; wherefore the weight of the metallic nickel is determined at 10 grains.

- a) The magnet has attracted these metallic grains with such rapidity, that, on its approach, the whole quantity adhered to it in an instant; and not one single globule remained behind.
- B) One grain of them by weight afforded, with fulphuric acid, affifted by heat, a grass-green folution; from which
- y) Ammoniae again precipitated the metallic part, of a bright whitish-green; but, on being affused in greater quantity, it soon re-dissolved it clearly, and of a skyblue colour.
- b) Five grains of this reduced nickel, dissolved in nitric acid, and thrown down by Prussian alkali, then edulcorated and dried, gave a sea-green precipitate; which, exposed to red-heat, left 15 grains of a granular residue, wholly attractible by the magnet.
- e) Those metallic grains urged by the flame upon charcoal, before the blow-pipe, exhibited no disposition to melt, or sufe, but turned to a greenish oxyd.
- ζ) When fused with borax, they likewise would not readily enter into sustain. The glass of borax turned ash-grey and opake; and the metal remained in it is a divided state.
- n) But with fufible phosphoric falt they melted pretty foon into one fingle bead, of a polyhedral furface. The glass globule, which, during the action of heat,

F f

was of a deep garnet-red, became transparent after cooling, and assumed a fine hyacinth colour.

e) Notwithstanding that all these facts, taken together, sufficiently demonstrate that the constituent part of chrysoprase, from which its peculiar green colour arises, is a true oxyd of nickel; yet I have, for the sake of superabundant evidence, made other experiments with an oxyd of nickel, which I prepared by the following method.

A portion of ore of nickel, from the pit König David, on the Sauberg, at Annaberg, was coarfely pounded, the pureft pieces selected, converted into a gross powder, and roasted in shallow pots, as long as any arsenical vapour exhaled. The powdered ore acquired, by this, a dirty green colour, and vegetated, in part, into ramified figures. This oxyd of nickel I reduced with black flux, and obtained a yellowishwhite, brittle, metallic button, of easy fusion. This, being once more calcined, was digested in a retort, with an equal quantity of firong fulphuric acid; after which the acid was again distilled over to dryness, and the residue re-dissolved in water, and filtered. At the beginning, the folution depolited small crystals of arsenic; and when these had been removed, the fulphated nickel shot into beautiful, deepgreen, rhomboidal crystals. This vitriol of nickel I again diffolved in water, and precipitated it by means of carbonated pot-ash. Upon the oxyd of nickel thus obtained, when washed, dried, and pulverized, ammoniac was affused. This last foon extracted a fine blue tincture, which, filtered off from the residue, was saturated with nitric acid; and, by means of mild pot-ash, all the whitish-green earth which it would yield was precipitated from it.

With this oxyd of nickel, extracted in this way from its ore, I have inflituted various experiments, for the fake of trial;

trial; which, to avoid prolixity, I shall not particularly enumerate. I will, therefore, only state, that this oxyd, as to the essential phenomena, has perfectly agreed with that extracted from chrysoprase.

f) Those who desire information respecting the habitudes of nickel in general, I refer to the valuable treatise of Bergmann\* on that metal; where he relates his experiments, made with unwearied patience, for the purpose of extracting the regulus of nickel, in a state of purity, from its ores, in which it is constantly accompanied by foreign metallic substances. The difficulties which take place in those processes, I have found confirmed by my own experiments: but I think the best method of obtaining the reguline part of nickel is that described above; namely, by means of ammoniac: yet the product becomes somewhat expensive.

In the chrysoprase, on the contrary, the oxyd of nickel is not mixed with other metallic matters, a very slight portion of iron excepted; and since the process which I have there given likewise serves to separate this inconsiderable ferruginous ingredient, we may safely consider the metallic nickel, produced from chrysoprase, or its accompanying green earth, to exist in the state of the utmost possible purity.

g) To this affertion, however, it may, perhaps, be objected, that the nickel obtained in that way still obeys the magnet, and, therefore, yet contains some iron. But has it as yet been unquestionably proved, that iron alone is subjected to the law of magnetic attraction?—Have the arguments which various philosophers have brought forward

<sup>\*</sup> Torb. Bergmann Opusc. Phys. et Chim. vol. II. page 231. De Niceolo.

against this supposition, been completely refuted?—When the chemist no longer finds any trace of iron in pure cobalt, or in pure nickel, and, nevertheless, observes the magnet to act upon it-can his doubt, whether the attractive force of the magnet be confined only to iron, as has been hitherto believed, be fairly rejected without any farther investigation?

- b) I must yet mention some experiments relative to vitristcation, for which I have used the rough chrysoprase, as well as the oxyd of nickel extracted from it, in combination with various other vitrifying media.
  - a) Rough chrysoprase, finely powdered and elutriated, . . . . . I part, Carbonated pot-ash, . . . . 2 parts,

mixed and fused in a crucible, afforded a violet-blue glass, which deliquesced in the air to a brownish fluid.

> B) Rough chrysoprase . . . 5 parts, Carbonated pot-ash 4 parts,

gave, after a fusion continued for two hours, a beautiful hard glass, of a violet-blue.

y) Rough chrysoprase . . } equal parts
Dry carbonated soda . . . } of each

vielded a tourmaline-brown glass, translucid only in thin fplinters. Its furface had fome delicate veins of reticular delineations; produced by extremely small grains of reduced nickel, lying close to each other in a linear range.

This reduction, which takes place without the addition of any combustible matter, is remarkable. Lehmann has before MELLIO. menmentioned a bead of reduced nickel, obtained from chrysoprase by reducing sluxes; but he mistook its nature, erroneously considering it as iron.

8) Rough chryfoprafe, and Calcined borax, in equal quantities,

gave a brown transparent glass, resembling rock-crystal of that colour. (Rauch-topas).

e) Prepared filiceous earth . . 80 grains,

Carbonated pot-ash . . . 60

Oxyd of nickel, from chrysoprase 3

yielded a clear, violet-blue glass.

By this experiment I obtained a glass of a violet-blue colour, perfectly resembling the last.

Ff3

n) Prepared filiceous earth,

Burnt borax; of each . . . 60 grains of each

Oxyd of nickel from chryfoprafe 3

produced a clear, light-brown glass.

Prepared filiceous earth
 Vitrified phosphoric acid, prepared from bones,
 Oxyd of nickel from chrysoprase

60 grains of each
3 grains,

have

i) Of the various inferences that may be drawn from the preceding facts, I will felect only a few.

Lehmann, to my knowledge, was the first, who observed that chrysoprase affords a blue glass by sustion with carbonat of pot-ash. This observation is confirmed by the experiments of Achard, made on the subject of the sufficient of various substances. The foregoing experiment ( $\epsilon$ ) shews, that this blue colour folely depends on the portion of nickel contained in chrysoprase; and it is proved, by the experiment ( $\zeta$ ), that the oxyd of nickel, if freed, as much as is practicable, from extraneous admixtures, possesses the property of tinging glass-frits, mixed with mild pot-ash, of a blue colour, on their vitriscation. But what can be the reason, that this blue colour is not produced by means of mild soda employed in the same manner? To what cause is that difference to be ascribed?

The fame experiments also prove that Le Sage \* was in the wrong, when he afferted that the metallic ingredient in chrysoprase is cobalt. Besides cobalt, we now know several metallic substances capable of producing a blue glass, under certain conditions, with which the chemist should be thoroughly acquainted, before he infers from this the nature of any metallic substance. Thus, cobalt covers all sluxes, (examels, glass-pastes) blue; while oxyd of wolfram (tungsten) imparts a blue colour to such frits only as are mixed with phosphoric salts, leaving, on the contrary, those

<sup>\*</sup> See Analyse Chimique et Concordance des Trois Règnes, par Mr. Sage, tom. II. Paris, 1786, page 73.

colourless that are combined with borax. In like manner, the oxyd of nickel tinges blue the frits prepared with carbonat of pot-ash; but brown, those into which carbonat of soda, or borax, enters; and, lastly, it produces a honey-yellow in such as are mixed with a neutral phosphat.

Since, therefore, chrysoprase does not afford a blue, but a brown glass, when melted with borax; this sact, together with the knowledge that no trace of any green sympathetic ink is discovered in its muriatic solution, is alone a sufficient evidence of the absence of any portion of cobalt from that soffil. Le Sage tells us, indeed, he has produced a blue glass from chrysoprase and borax; but again this affertion of his does not correspond with experience.

[ 440 ]

#### XLV.

### CHEMICAL EXAMINATION

OF THE

### NOBLE OPAL,

From Cscherwenitza, in Upper-Hungary.

If the Noble Opal, effulgent with variegated colours (chatevant) be contrasted with the colourless rock-crystal and the dull, dark coloured stint, it would hardly be possible, were it not for the conviction afforded by chemical experience, to be persuaded that the chief constituent part of those three species of stones, so dissimilar in their external appearance, is the same simple, pure, siliceous earth, or, at least, only in exceedingly small proportions, mingled with soreign ingredients; and that it is only the difference in the state of aggregation which modifies the one to opal, the other to rock-crystal, and the third to slint.

But that the *moble opal* \* really belongs to the purest forts of filex, is demonstrated by the following analysis.

<sup>\*</sup> Eftner has published in his Mineralogy, vol. II. page 402 feq. an ample description of this beautiful stone; taken principally from the valuable opals in the Imperial Cabinet at Vienna, so distinguished by their beauty and magnitude; and, besides, from those in the collection of opals of Abbé Neumann, Director of the Imperial Cabinet of Medals, which, perhaps, is the most complete in its kind. Of the accurate agreement of those descriptions with the originals, I had the pleasure of convincing myself by my own inspection, at Vienna.

A piece of rough, or unwrought noble opal, weighing 76½ grains, was exposed to fire, in a well-covered porcelain-vessel. It crackled at the very first degree of heating, When the noise caused by this had ceased, it was kept in ignition for half an hour longer. After cooling, it was found burst into small slaty splinters, of a pure milk-white, and a surface partly glittering, partly of an enamellustre. The yellowish ferruginous covering, which is perceivable even in the rough stone, and penetrates its extremely minutes sissures, was changed, by the ignition, to a high-yellow-red, and, in part, iridescent, or exhibiting changes of rainbow colours. It experienced a loss of weight of 7½ grains, or about 10 per cent.

#### B.

a) Hundred grains of rough, noble opal, finely-pulverized in the flint mortar with water, were mixed, after exficcation, with 200 grains of dry carbonated foda, and fubjected to moderate red-heat for two hours, in a filvercrucible.

The mass, which but loosely coalesced, was then triturated, softened with water, super-saturated with muriatic acid, and briskly digested. The sluid formed a gelatinous coagulum as it cooled. When diluted with more water, and again digested, it was filtered, and the filiceous earth remaining on the paper thoroughly lixiviated, and ignited, after previous drying. It then weighed 90 grains.

c) The muriatic liquor was reduced to a small bulk by evaporation, and treated with caustic ammoniac, added in

excess. But only a very small quantity of brownish flocculi separated, consisting merely of iron, and amounting to to of a grain, when collected and ignited.

But, fince the very pure white colour of the ignited opal evidently proved, that this flight portion of iron does not effentially belong to its mixture; and fince, befides, not the least perceptible trace of alumine appeared, I can only reckon as real conflituent parts, in the opal here examined, the following:

Silex	 		90.
Water			10
		-	

### [ 443 ]

### XLVI.

#### CHEMICAL EXAMINATION

OF THE

### SAXON HYDROPHANES\*.

AMONG those varieties of opal, which are known by the names, bydrophanes, changeable opal, oculus mundi, and possess the remarkable property of becoming transparent in water or other sluids, those from Saxony are, besides, particularly distinguished by the beautiful opalescent play or change of colours, which they exhibit in that situation, of which some exhibit sensible indications, even in their natural dry state.

Yet, although hydrophanes has been analysed by various persons, the proportions of its constituent parts are stated very differently.—From this disagreement, Wiegleb was induced to institute a new examination of this stone, which made it appear, that the argillaceous ingredient, to which that peculiar physical property of hydrophanes has been erroneously attributed, is a much smaller constituent part than has been afferted by various authors.

This investigation, made by Wiegleb, does not thoroughly agree with the result of that which I performed with various hydrophanes, kindly given me by Baron Racknitz, of Dresden, and found at Selitz, near Hubertsburg. This learned connoisseur and respectable promoter of mineralogical science likewise confirms the circumstance related by Wiegleb, that hydrophanes, while in the mine, is soft; and,

<sup>\*</sup> Chemische Annalen, 1790, part I. page 61. Chemische Annalen, 1789, part I. page 402,

## 444 XLVI. Examination of the Saxon Hydrophanes.

in this state, susceptible of receiving impressions from hard bodies.

- a) One hundred grains of this Saxon hydrophanes were coarfely divided or bruifed, and ignited upon red-hot coals, in a fmall glass retort. At the end of this process there appeared, in the receiver, an empyreumatic water, covered with a thin greafy pellicle. The loss of weight arising from this was  $5\frac{1}{4}$  grains.
- b) The ignited hydrophanes was then triturated to a subtle powder, mixed with twice its weight of carbonated soda, and kept in a moderate heat for two hours. When the mass had cooled, it was powdered, super-saturated, and digested with dilute muriatic acid. This done, the muriatic studies fluid filtered off from the siliceous earth, that had much swelled, together with the lixiviating water, was concentrated by evaporation, and saturated with caustic ammoniac; by which, however, only a small precipitate was produced, consisting of pure alumine, unmixed with iron, and weighing 15 grains after ignition. Nothing farther was found in the remaining liquor.

Hundred parts of this hydrophanes, from Saxony, therefore contain:

Silex .				4			93,125
Alumine						9	1,625
Volatile in	nfla	mm	abl	e pa	rts,	ber	
and wa				-			5,250
							100

If this hydrophanes, after complete expulsion of its aqueous moisture, be steeped in melted wax or spermaceti, in which state of artificial preparation it is called *pyrophanes*; it acquires the property of being quite translucid, and of a brown yellow or grey colour, when heated in a spoon upon a charcoal fire.

XLVII.

#### XLVII.

#### CHEMICAL EXAMINATION

OF THE

### WHITE AND GREEN OPAL

From Kosemütz \*.

AMONG the different stones that accompany the chrysoprase in its veins, on the mountainous district of Kosemütz, there also occur various forts of opal, which ought to be classed partly with the common (dull) opal, partly with the semi-opal. They are there found chiefly of four colours, viz. green, reddish, yellow, and milk-white; of which the three last varieties belong to the common-opal, and mostly lie on a grey and brownish hornstone.

The subject of this enquiry was the milk-white, inclining to the blueish and transparent variety of that common-opal.

- a) Half an ounce of this fosfil, most finely levigated, and intimately mingled with one ounce of desiccated soda, was moderately ignited for two hours. The mass, obtained and ground to powder, was saturated to excess with dilute muriatic acid; then evaporated nearly to dryness, again diluted with water, and finally thrown upon the filter. The residue, lixiviated, dried, and ignited, gave 237 grains of filiceous earth.
- b) The fluid, diminished by evaporation, and combined with caustic ammoniac, afforded a slight quantity of a brownish

<sup>\*</sup> Beobachtungen und Entdeckungen aus der Naturkunde. Berlin, 1788, vol. II. page 45.

precipitate.

## 446 XLVII. White and green Opal of Kosemutz.

precipitate. As the remaining liquor continued unaltered, on being combined with carbonat of foda, it shewed, by this, that it held no other substance in solution.

c) When the precipitate, obtained by means of caustic ammoniac, had been redissolved in muriatic acid, and treated with prussiat of pot-ash, it afforded some Prussian blue, of which the oxyd of iron, that enters as a constituent part into this opal, was, at most, one-quarter of a grain. After its separation, carbonat of soda still precipitated half a grain of aluminous earth, which, upon ignition, could not be estimated at more than one-quarter of a grain.

This common opal, therefore, chiefly confifts of mere filiceous earth; for one half ounce of it yielded:

Silex	. 237 grains 0,25
Lofs .	237,50
The same of the same	240 grs. or ½ oz.

The apple-green variety of those opals from Kosemütz, which it will be more proper to rank under the semi-opal, penetrates like the chrysoprase, in clests or veins, of from one-half to one full inch thickness, those masses of earths and stones, which lie promiscuously in irregular strata in the mountains which afford chrysoprase. The constituent parts of this green semi-opal are likewise those of the foregoing common white opal, only that it contains about one per cent. of oxyded nickel, from which, likewise, its green colour, like that of chrysoprase, originates.

XLVIII.

## shair a ni begisamu XLVIII. ci. s numani man a bas

# CHEMICAL EXAMINATION

n day leganished to a felly got

# YELLOW OPAL from Telkebanya.

on the pape to wanghed 93F grains, when ig-

FOR the analysis of this species of opal, expressed by the name pitch-opal, telkebanya-flone, I selected that clear greenish-yellow variety, which in gross splinters resembles the bright-yellow common amber (electrum, succinum).

a) Hundred grains of it, broken into coarse fragments, were subjected to red-heat for half an hour in a covered crucible. The stone slew in pieces, with a moderate decrepitation or crackling noise. It was slightly transparent, after this ignition, but only on the edges; its colour also changed into a pale brown-yellow, and the loss of weight, which it sustained, amounted to five grains. At the same time it became very soft, and allowed of being easily ground to a subtle isabella-yellow powder.

A stronger heat renders this opal greyish-white. The slight portion of iron which it contains, and from which it derived its colour, is reduced, in this process, to the reguline state; and, by means of a good magnifying lens, extremely fine grains of iron, that have transuded, may then be discovered \*.

b) The above-mentioned 95 grains of ignited and pulverized opal were mixed with 200 grains of effloresced mild

# 448 XLVIII. Yellow Opal from Telkebanya.

foda, or fuch as had lost its water of crystallization in the air, and in that situation exposed to, and maintained in, a moderate red-heat during the space of one hour. The mixture came out of the fire quite white, and but loosely conglutinated. It was next softened with water; supersaturated with muriatic acid; concentrated by evaporation to a jelly; once more diluted with water; and, lastly, thrown upon the filter. The filiceous earth, which, by this management, remained behind on the paper, weighed 93½ grains, when ignited.

t) I then treated the colourless muriatic fluid with caustic ammoniac, added in an over proportion. But only a few brown flakes separated, which, when collected and ignited, afforded one grain of oxyd of iron. The remainder of the fluid contained no other ingredient.

Accordingly, hundred grains of this yellow opal, from Tel=kebanya, confift of:

				99,60
Water	1			5
Oxyd	of i	ron		I
Silex		4		93,50

#### XLIX.

## CHEMICAL EXAMINATION

OF THE

# BROWN-RED SEMI-OPAL From Telkebanya.

THIS fossil, which occurs but seldom in the Telkebanyamountains, and by some has been erroneously considered as a red pitch-stone, possesses a brown-red colour; is massive, and of moderate brilliance. Its fracture is slat conchoidal, and its texture compact and smooth. It is opake, brittle, and bursts easily. By reduction to a sine pulverulent state, it acquires a fully saturated deep-red colour, similar to that of powdered resin, called dragon's-blood. Its specific gravity I found to be 2,540.

a) When entire pieces of it were strongly ignited for half an hour, in a covered crucible, it neither slew in pieces, nor experienced any change of colour; but it lost  $7\frac{1}{2}$  per cent. of weight.

But when exposed to the more intense heat of the porcelain furnace, the phenomena take place, which have been mentioned in Essay I. No. 65. For, if ignited in the charcoal crucible, a great number of grains of iron transude, and the fracture of the stone becomes grey, dull, earthy, very rough and porous, like spunge. If ignited in the clay-crucible, its whole surface is covered by a fine-scaly ferruginous crust, of a metallic lustre, and attractible by the load-stone. It is, indeed, an unexpected phenomenon, and hence the more remarkable, that iron, so strongly oxyded as it is when sontained in this sossil, has, in the latter instance, been re-

Gg

# 450 XLIX. Brown-Red Semi-opal from Telkebanya.

duced to the reguline state, so as to obey the magnet; and this, without any admixture of charcoal, or any other substance of a nearer affinity with oxygen.

- b) Hundred grains of the fossil, most finely levigated, were mixed with a caustic alkaline lye, containing 300 grains of the salt. This mixture, being first inspissated to dryness in a silver vessel, was then ignited for half an hour. After re-frigeration, I softened the mass with water, superfaturated it to a great excess with muriatic acid; and having inspissated it to a gelatinous consistence, I diluted it again with water, digested and filtered it. The filiceous earth, then obtained and ignited, weighed  $43\frac{1}{2}$  grains.
- c) The yellow muriatic folution was combined with caustic ammoniac to over-saturation. A quantity of brown oxyd of iron, rather in large proportion, fell down, which weighed 47lb. when washed, dried, and ignited. The studies by this remained unchanged, when combined with mild alkalis.
- d) This oxyd of iron was re-diffolved by digeftion, in muriatic acid, and precipitated by Prussian alkali. After the separation of this blue precipitate of iron, the remaining solution was examined, first with caustic ammoniac, and next with mild soda. It suffered no change in either case.

Wherefore this fossil, which, from its large proportion of iron, might, perhaps, deserve to be classed under the genus of iron, with the denomination of opaline iron stone, is, in the hundred, composed of:

Oxyd of iron	19.19	0.1.79	47
Silex	•		43,50
Water .		.oqui	7,50
	100		98

## CHEMICAL EXAMINATION

OF

## MENILITE\*.

HE fossil here treated of, and of which Delabre and Quinquet have given the first notice +, is found at Menilmontant, near Paris. It there occurs at a depth from 60 to 80 feet under a feam of clay (Thombank), in a stratum of stones that belong to Werner's polishing slate, and is found in larger or fmaller pieces, for the most part detached, and kidney form, or rather in nodules. The colour of its external furface is a tarnished blue; but its fracture is of a hair-brown, with fome greafy luftre. Its texture appears externally foliated or fine-flaty. This, however, is to be confidered merely as impressions from the adhering finely-lamellated gangue or matrix; and should be distinguished from the coarse slaty texture of the stone itself, which can only be observed when feparate. It readily bursts into fragments, which are flatconchoidal in the cross fracture, but coarse-splintery in the longitudinal fracture, and are transparent in the edges. It cuts glass, though it greatly yields to the file, which produces a grey-white streak on it. When it is struck with fteel, only a few fingle sparks are emitted. Its specific gravity is 2,185.

In the fystematical arrangement of minerals, this stone has formerly been reckoned among the genus of clay, and accordingly placed as a variety of pitch-stone, with the name blue pitch-stone. Against this, an anonymous author has

<sup>\*</sup> Chemisch. Annal. 1790. 2 Th. S. 297.

<sup>†</sup> Journal de Physique, Paris, Sept. 1787.

ftarted some doubts, in a letter to de la Metherie ‡, in consequence of experiments which he has made, by moistening some pieces of the stone, and exposing them for several months to open air; upon which he sound, that sulphat of magnesia had gradually been formed. By this he was persuaded, that this species of stone belongs to the magnesian genus, and should be added to the steatites, serpentine and pot-stone. With what propriety, will appear from what follows.

#### A.

From the pieces chosen for this enquiry I first separated the earth adhering to their outfide. I then introduced hundred grains into a small glass retort, inserting its neck into a bottle containing lime-water. The retort was placed between the coals, or in open fire, and the heat gradually increafed to the ignition of its contents. At the very beginning there passed over some drops of water, and soon after I faw the lime-water in the receiver growing turbid. In this last, when the receiver had been removed, I perceived a bituminous-empyreumatic finell, which, at first, also seemed to be somewhat ammoniacal. The pieces of the stone in the retort were rendered black and resplendent, like jet (Gagas), and had lost eight grains. But by a still stronger ignition in an open crucible, they loft again that black colour, and became at first blueish, then grey-white, losing, at the same time, three grains more in weight.

I then combined them, previously ground to fine powder, with double their quantity of carbonated pot-ash, and put them into an open fire, in a silver crucible. The mixture entered into sussing, without my intending it, and soamed so

<sup>\*</sup> Journal de Physique, Paris, Fevr. 1789.

strongly that it lifted up the lid of the vessel, and run over in part. Seeing this, I directly withdrew the crucible from the fire, and found that the remaining portion of the mass had melted into a clear greenish glass; which, as it cooled, attracted moisture from the air, and dissolved entirely in a little water.

Although I could not farther proceed in this examination, on account of having loft part of the mass; yet I foresaw, from these facts, that this fossil is not a very compounded species of stone, but rather that it is likely to consist almost entirely of mere siliceous earth. This conjecture was again confirmed by the following experiment.

#### B.

- a) I reduced one hundred grains of the rough stone to an impalpable powder; and having mixed them with twice their weight of carbonated pot-ash, I ignited the mixture in a silver crucible, during sive hours, in a degree of heat so moderate, that there was no danger of its susing. When triturated, it dissolved in water, assisted by heat, leaving only a few undissolved particles. By super-saturation with muriatic acid, the mixture congealed to a thick, intumesced slime. After farther dilution with water, digestion, and siltering, there remained 84 grains of siliceous earth, upon being washed, dried, and heated to redness.
- b) When the fluid, separated from this last, had been concentrated by evaporation, and, while yet hot, saturated with mild soda, a brownish-white precipitate fell down; which, being re-dissolved in nitro-muriatic acid, there still separated some siliceous earth, weighing 1½ grain, when ignited.
- c) The liquor, freed from this, was treated with Prussian alkali; and the quantity of the blue precipitate then pro-

duced indicated half a grain of oxyd of iron, attractible by the magnet. After the separation of this last, aluminous earth, weighing one grain in the ignited state, was thrown down by caustic ammoniac. Carbonated soda, with the affistance of heat, precipitated from the remaining sluid a slight portion of loose earth, which, after ignition, scarcely weighed half a grain, and, upon trial by sulphuric acid, showed itself to be calcareous earth, accompanied by a trace of magnesia.

In confequence of this analysis, hundred parts of menilite contain:

Silex .				85,50
Alumine	-1 .			I
Oxyd of	iron			0,50
Lime				0,50
Water o	and car	rbonic	: matter	II,
				98,50

From the conflituent parts here produced, it is obvious, that this fossil can, by no means, belong to steatites, or to serpentine, or to the pitch-stone, as the proportions of those ingredients, in conjunction with the infusibility of menilite\*, sufficiently prove. Perhaps this fossil may be considered as a variety of the semi-opal, approaching to shirt (Feuerstein).

The inconsiderable trace of magnesia does not seem to belong to the mixture or composition of this fossil. It rather originates from particles, that have entered into it from its matrix, which contains a small portion of magnesia, as will appear by the following analysis.

<sup>\*</sup> See Essay I. No. 69.

#### LI.

## CHEMICAL EXAMINATION

OF THE

#### POLISHING-SLATE

(Polierschiefer of Werner.)

From Menil-montant.\*

THE polishing-flate, found at Menil-montant, which serves as a matrix to the menilite, spoken of in the last Essay, possesses a bright white-grey colour; is meager and rough; of a dull earthy fracture; strongly adhering to the tongue; and split, in a slaty manner, by slender horizontal rists. Its specific gravity is only 2,080. When thrown into water, it imbibes it with a crackling noise, and copious air-bubbles are disengaged. By trituration it affords a very loose powder, which, on ignition, loses 19 in the hundred, and acquires thereby a pale red colour.

I shall not relate in detail the method by which I performed its decomposition, as it was the same with that of the preceding fossil. But I shall only mention the result, according to which the constituent parts of polishing-slate, and their proportions to one another, in the hundred, are:

Silex .			,		66,50
Alumine				- 0	7
Oxyd of i	ron			•	2,50
Magnesia					1,50
Lime .	•				1,25
Water		• ,		*	19
					97,75

<sup>\*</sup> Chemische Annalen, 1790. 2ter Theil. Seite 302.

LII.

## CHEMICAL EXAMINATION

OF THE

# SILICI-MURITE (Meerschaum.)

From the Levant \*

THE plastic filici murite (myrsen, kil, keffekil) from Eski-Scheher, in Natolia, the external characters of which, along with some observations upon it, have been given by Kar-sten +, should, on account of its exterior appearance, be rather added to the argillaceous genus, and in particular to the species of tripoli, than to the genus of magnesian earths, under which it has been placed since its analysis, published by Wiegleb ‡

However, as it appears from the paper of Wiegleb, that the filici-murite decomposed by him was not then in its crude native form, but had been wrought into tobacco-pipe heads, and as from this circumstance it might become doubtful whether the fossil, employed by him in that state, was genuine; I thought it of some use to repeat his enquiry, by analysing some genuine silici-murite in its natural state.

For this purpose I selected two varieties; the first of which differed from the other, by a whiter colour, a somewhat smaller degree of hardness, and a greater looseness when powdered.

<sup>\*</sup> Beob. u. Entd. a. d. Naturkunde, vol. V. Berlin, 1794, page 149. † Loc. cit. page 143.

<sup>1</sup> Neuste Entdeckungen in der Chemie, 5 Theil. Seite. 3.

#### A.

- a) The specific gravity of the whiter variety in pure lumps, freed from their porphyraceous matrix, is 1,600. Of this I subjected bundred grains to a brisk red-heat in a crucible, by which they lost 30 grains. But, in other respects, they suffered no alteration observable in their external appearance: as, by the result of a previous experiment, hereafter to be mentioned, the loss of weight, which this fossil sustains by ignition, is five parts of water and one of carbonic acid. The above loss of 30 grains is, consequently, divided into 25 grains of water and five grains of carbonic acid.
- b) The remaining ignited 70 grains were ground to a most subtle powder, which I first worked with water to a pulpy consistence. Half an ounce of strong sulphuric acid was then added, and all the suid distilled over to dryness. The residue being softened with boiling water, its undissolved portion was separated by means of the filter. Which last, edulcorated, dried, and ignited, consisted of 50½ grains of white, very loose siliceous earth.
- c) The clear, colourless liquor shewed, by the taste, that it was a solution of *fulphated magnesia*. When concentrated by evaporation, it deposited, as it cooled, a small quantity of selenite, in tender spear-shaped crystals. This being decomposed by mild ammoniac, afforded one grain of carbonated lime, for which half a grain of pure calcareous earth must be reckoned.
- d) When the felenite or fulphated lime had been feparated, the folution yielded, by crystallization, only sulphat of magnesia. From this salt, re-dissolved in water, and decomposed in a boiling heat, by carbonat of pot-ash,  $37\frac{1}{2}$  grains of carbonated

bonated magnefia were obtained, which were reduced, after an hour's ignition, to 17½ of pure magnefia.

An hundred parts of this whiter filici-murite, therefore, contain:

Silex		b)	v		50,50
Magnesia .		d)			17,25
Lime					
Water		a)			25
Carbonic acid	0	a)			5
					98,25

I could not ascertain, in the burnid way, the proportion of the carbonic acid ingredient in this fosfil; fince acids do not completely diffolve or decompose it in the cold, and hence do not at all effervesce with it, or only imperceptibly. For this reason, I attempted it in the dry way. I introduced 200 grains of pulverized filici-murite into a small glass retort, connected with the hydrargyro-pneumatic apparatus, and kept it in ignition until the veffel was near fufing. The water that passed over I collected in the intermediate small fpherical cavity of the conducting pipe, while the gas was caught in a receiver above the mercury. The water weighed 35 grains. It was yellowish, and emitted a smell like petroleum; it also manifested an obscure vestige of ammoniac, which, however, was foon after fucceeded by a feeble trace of an acid. But the gas, deducting the common air contained in the apparatus, amounted to 13 cubic inches, whose weight is nearly seven grains. This was entirely absorbed by lime-water, from which it precipitated carbonated lime or crude calcareous earth.

#### B

The other fort of filici-murite, the colour of which inclined to the grey, lost 39 grains in the hundred, and acquired by it

whiteness of chalk. Its decomposition was performed in the same manner as that of the foregoing. In the result, the folloing appeared to be its constituent parts in the hundred:

Silex								41
								18,25
								0,50
Water	an	d c	arb	onic	ac	id.		39
							-	
								98,75

Besides these two varieties of filici-murite, I have likewise analysed a third, in which I have found the proportion of magnesia considerably greater, but that of silex much smaller in the same ratio. But as this consisted of one single fragment only, I was not able to repeat the experiment. Yet I mention this, because it shews that Nature does not always observe an invariable proportion in the two chief constituent parts of silici-murite; as, indeed, is also the case with respect to various other fossils.

LIII.

## CHEMICAL EXAMINATION

OF THE

## SEMI-INDURATED STEATITES.

(Speckstein of Werner.)

From Bareuth.

THOUGH the common Steatites, which occurs at Göpfersgrün, near Wunstedel, in the principality of Bareuth, is
found in confiderable quantity, yet it has till now been met
with only in detached, larger or smaller, renisorm lumps.
It is distinguished from other species of stones of the same
genus particularly by this, that it is found sometimes in hexahedral prismatic crystals, with six-sided pyramidal terminations, and, but very lately, in double hexahedral pyramids\*,
imbedded in massive indurated steatites.

- a) Two hundred grains of this steatites, finely scraped by the knife, were subjected to red-heat, in a covered crucible, during one hour. They lost by this 11 grains of weight, and the ignited powder of the stone received an isabellayellow colour.
- b) This powder I mixed in a filver-crucible with a cauftic lye, of which the alkaline part, or the pot-ash, was double the weight of the pulverized stone; and, after having evaporated it to drynes, I kept it in ignition for half an hour. This mass was again dissolved in water, and digested

<sup>\*</sup> This rare crystallization of the Bareuth-steatites, resembling the double hexahedral, calcareous, Derbyshire-spar, is found in the collection of Mr. Frick, Master of the Mint at Berlin.

with muriatic acid, added in excess. Siliceous earth was thus separated, amounting to 119 grains, after washing, drying, and ignition.

- c) The muriatic folution was combined with carbonat of pot-ash, heated to the degree of ebullition. The brownish precipitate, thereby produced, was treated with muriatic acid; the solution evaporated, and the dry saline mass strongly ignited during half an hour. Having re-dissolved this saline mass in water, and separated the brown oxyd of iron by filtration, I combined the clear solution with carbonated pot-ash, at the temperature of boiling. By these means, 147 grains of very loose and white magnesia were precipitated. One half of this, re-dissolved in sulphuric acid, and crystallized, afforded pure sulphat of magnesia. The other half, when heated to redness, weighed 30½ grains.
- d) The brown-red oxyd of iron, that had separated from the aqueous solution of the ignited saline mass (c), weighed nine grains. But, as the portion of iron, existing in the mixture of steatites cannot be considered as perfectly oxyded, but only as being in the state of an oxyd of iron, still attractible by the magnet, I deslagrated linseed-oil upon it, in a covered crucible.—This oxyd of iron now weighed only five grains.

According to this analysis, the Steatites from Bareuth consists, in bundred parts, of:

Silex	b)					59,50
Magnesia	(2)					30,50
Oxyd of iron	d)					2,50
Aqueous particles, drive	en out	bya	red-	hea	it	5,50

LIV.

## CHEMICAL EXAMINATION

OF THE

## STEATITES FROM CORNWALL\*.

(Soap-rock, Seifenstein.)

HE Steatites of Cornwall (Talcum Smectis, Lin.) occurs at the Cape Lizard, in ferpentine mountains, which it cuts through in small, perpendicular, or rake veins. The finest fort of it is white, with blueish, or reddish spots, resembling marble. While fresh from the mine, it is so soft, that, like foap, it may be abraded with the knife. It is used in making porcelain. The working of these mines is carried on by the House of the Porcelain-manufacture at Worcester; which pays 201. fterling for the ton, at 20 cwt.; because, the bringing it out to the day is extremely uncertain and dangerous, the serpentine rock breaking in so frequently. There also occurs in these mines another fort of it, less fine, and having fpots of iron-ochre; as well as a third, brown-red variety, mingled with green. Not far from thence, at Ruan minor, also in serpentine, there is found, both a greywhite and a light-flate-blue foap-rock, or fleatites, and also a whitish steatites, crossed by calcareous spar, which gives it a smooth, shining fracture.

It was the first, finest fort of steatites, that was the subject of the following analysis.

<sup>\*</sup> Beobacht. u. Entdeck. a. d. Naturkunde, vol. I. Berlin, 1787, pages 163 and 192.

- a) One ounce of it, in selected pieces, was exposed to an intense red-heat, placing the glass-retort in open fire. There distilled over a little pure tasteless water. The steatites lost thereby 75 grains, and acquired a somewhat darker colour, and a considerable degree of hardness.
- b) It was next, after previous pulverization, intimately mingled and ignited with two ounces of carbonat of potash in a porcelain-pot. The concreted mass was levigated with water, and digested with an over-proportion of muriatic acid. By this, a large quantity of a white, loose, slimy earth, subsided; which, upon edulcoration, drying, and exposure to red-heat, weighed 204 grains, and was pure slikecous earth.
- c) When the filtered solution had been combined with Prussian alkali, a blue precipitate arose, which I collected, washed, dried, and ignited with a little wax. The whole of it obeyed the magnet, and weighed seven grains; of which, subtracting the portion of iron belonging to the prussiated pot-ash employed, 3\frac{3}{2} grains are the oxyd of iron, entering as a constituent part into steatites.
- d) From the folution, freed from iron, I now precipitated its earthy ingredient, by carbonated pot-ash. It weighed 192 grains, when washed, and gently ignited. These were covered with a proportionate quantity of distilled vinegar, somewhat concentrated by freezing; and, after this, digested in a low heat, and thrown upon the filter. The earth that remained on the paper, and which weighed 93 grains, when desiccated and ignited, was mixed with three times its weight of strong sulphuric acid; the mixture evaporated nearly to dryness in a sand-heat; the dry saline mass liquested in water; and, lastly, siltered. By this treatment there yet remained 26 grains of siliceous earth.

# 464 LIV. Examin. of Steatites from Cornwall.

- e) The fulphuric folution (d), therefore, contained 67 grains of earth; which, precipitated by alkali, and examined in the usual way, was found to be merely aluminous earth.
- f) Of the first 192 grains of the earthy precipitate (d), 99 grains were taken up by the acetic acid. These I likewise precipitated by means of carbonated pot-ash. The earth thus obtained was tried by sulphuric acid, and found to be mere magnesia.

Therefore one ounce, or 480 grains, of this Steatites from Cornwall have yielded:

		204 grs.}		230 grs.
Magnesia				99
Alumine	e)	dr. tariana	14	67
Oxyd of iron .	(c)		91	3,75
Water				75 .
to him and and to double double double double		Lofs	100	474,75 5,25
				480

Or, an hundred parts of it, averaging the small fractions, contain:

Silex			48
Magnesia .			20,50
Alumine .	115		14
Oxyd of iron		1.5.	I
Water			15,50
			-
			99

## CHEMICAL EXAMINATION

OF THE

# CHINESE AGALMATOLITE.

(Plastic stone. Bildstein.)

BY the name Plastic Stone (agalmatolithus), I denote that fossil, which hitherto has been called Steatites from China; fince this last denomination of it, as indicating a stone belonging to the magnesian, or muriatic genus, can no longer be retained with propriety, as will appear from the following analysis of that fossil.

The want of rough pieces of this stone I supplied by employing figures cut of it; the genuineness of which is rendered indisputable by the known peculiar taste or character of the Chinese art.

On breaking feveral of these little carved figures, I obferved that two varieties may be distinguished of the stone used for them by the Chinese artists; which I denominate the transparent and the opake.

#### A.

# Transparent Chinese Agalmatolite.

The colour of this is olive and asparagus-green, verging through various shades to a greenish-blue. Inwardly it is very much glittering, and of a greasy lustre. The chief fracture is indistinctly thick-slaty, but the cross-fracture H h evidently

evidently small-splintery. It is strongly transparent, inclining to the semi-translucid; soft, and of a greasy feel, &c. Its specific gravity, 2,815.

- a) Two hundred grains of this agalmatolite, finely ground, loft 11 grains of weight by a moderate ignition for half an hour.
- b) After the first ignition, the powder of the stone was mixed with equal parts of carbonated soda, and once more subjected to red-heat for half an hour in a silver-crucible. The mixture returned from the fire in the form of a moderately coalesced powder. I diluted it with water, and super-saturated it with muriatic acid; which dissolved the whole of it without leaving any observable residue. But when the solution had been put in a sand-heat to evaporate, it formed a thick gelatinous coagulum; and after digesting it for some time, it was filtered. The collected siliceous earth, washed and ignited, weighed 105½ grains.
- c) The muriatic folution, faturated with caustic lixivium, thickened to a milk-white mass. By a slight excess of the alkaline lye, it again dissolved entirely to a limpid, colour-less sluid, leaving only a few light-brown, loose slakes, which, upon edulcoration and ignition, weighed four grains.
- d) These four grains of brown residue were treated by digestion with muriatic acid. Siliceous earth, weighing  $2\frac{1}{2}$  grains in the ignited state, was then separated. This done, the solution was combined with prussiant of pot-ash, and the blue ferruginous precipitate, thereby produced, was collected. Nothing else was found in the remaining sluid. The portion of iron, which it contained before, amounted to  $1\frac{1}{4}$  grain.

e) The alkaline folution (c) was faturated to excess with fulphuric acid, and then combined, in a boiling heat, with carbonated soda, to precipitate its earthy contents. The earth, thus obtained, was lixiviated and dried; and afterwards depurated by means of distilled vinegar and ammoniac. Upon deficcation, it weighed 122 grains; but upon ignition, only 72. It was found to be pure aluminous earth; for, when re-dissolved in sulphuric acid, and crystallized with an adequate proportion of acetated pot-ash, it afforded only sulphat of alumine.

Wherefore, the transparent variety of the Chinese agalmatolite, calculated for an hundred parts, contains:

Silex	. b) . d) .	523/4 }	
Alumine Oxyd of iron . Water	. e) . d) .	deficit bio.	. 36
			96,25

B.

## Opake Chinese Agalmatolite.

This variety of agalmatolite is reddish-white, flesh-red, and of variously coloured veins. Its fracture is dull, and less distinctly splintery. It is opake, or only very little transparent on the edges; very soft; and seels very greasy. The specific gravity of it is 2,785.

a) Two bundred grains of it, finely scraped off from the mass, sustained a loss of 20 grains by ignition. Its original reddish-white colour was by this process changed to a grey.

H h 2

b) This

- b) This ignited powder was a fecond time exposed to red-heat for half an hour, in a filver-cruible, with its own quantity of desiccated mild soda; which caused it to conglutinate but moderately. The mixture, previously drenched with water, was combined with an over-proportion of muriatic acid, and the solution evaporated to a jelly.—When this had again been diluted with sufficient water, it deposited siliceous earth, amounting to 122 grains, when collected on the filtering paper, and subsequently lixiviated and ignited.
- c) The muriatic folution was afterwards decomposed by carbonated pot-ash, and the thorough separation of the precipitating earth was promoted by boiling. The precipitate, which subsided in a highly swelled state, was lixiviated, and while yet moist, brought into a warmed alkaline caustic lye; in which it dissolved in an instant, and left only a slight brownish residue.
- d) Muriatic acid entirely dissolved this residue. By combination with Prussian alkali, Prussian blue sell down, the quantity of which denoted one grain of iron in the stone. The stuid was next, after the separation of the iron, decomposed in a boiling heat by dissolved carbonat of pot-ash, which precipitated a white earth. This last effervesced moderately with sulphuric acid that was poured upon it, and deposited gypsum; the quantity of which increased, in proportion as the volume of the mixture was reduced by evaporation. It weighed, after ignition, five grains, equal to two grains of pure calcareous earth in the ignited state. The small quantity of the stuid yet remaining shot into crystals of sulphat of alumine.
- e) The portion which had been taken up by the alkaline lye (c) was thrown down by means of fulphuric acid, but

it dissolved again by a slight excess of the solvent. The alum last obtained, (d), was then added to it, and the whole precipitated asresh by carbonat of pot-ash, assisted by a boiling heat. When afterwards edulcorated, dried, purified by means of vinegar and ammoniac, and finally heated to redness, the precipitated alumine weighed 50 grains.

f) I then poured sulphuric acid upon it, and inspissated the mixture on a sand-bath. The turbidness of the sluid, on being again dissolved in water, was caused by the tender siliceous earth, which then separated, and consisted of two grains after ignition. This being subtracted, the quantity of aluminous earth (e) is reduced to 48 grains; which now, by combination with acetite of pot-ash, and crystallization, continued to the end to shoot into alum only.

It follows, from this decomposition of the opake variety of the Chinese agalmatolite, that its constituent parts give in the hundred:

Silex		6)	61	}		62
A		f)	I.	)		
Alumine .	*	f)				24
Lime		d)				1
Oxyd of iron						
Water						
						97,50

Several examples have shewn, that, in the systematical arrangement of fossils, the light of chemistry should be the guide; and I think the present analysis surnishes one of the most conspicuous proofs of that point. The three fossils, which were the subject of this and the two preced-

Among the other stones, also manufactured by the Chinese into figures, or little statues, I have likewise met with a white, pure, very finely grained marble; which, by bare inspection, is sufficiently distinguished from the Chinese agalmatolite here treated of.

[ 471 ]

LVI.

#### ADDITION

TO THE

## CHEMICAL EXAMINATION

OF

## LEPIDOLITE\*.

SINCE the analysis of Leucite, described in the earlier part of this work, has evidently proved that it contains the vegetable alkali as one of its essential constituent parts; it was to be expected that this alkaline substance might likewise be found in the mixture of various other species of stones and earths. The first confirmation of this conjecture has been afforded to me by the Lepidolite.

In the examination of this stone, here quoted, the loss of weight in the sum of its constituent parts, which I could not then farther account for, amounted to  $6\frac{1}{2}$  per cent. + As I suspected that this loss might arise from the vegetable alkali, which at that time was not yet known as a co-constituent part of soffils, I resolved to undertake a second analysis of lepidolite.

#### A

I reduced, by grinding, 250 parts of the amethystine red lepidolite to as fine a powder as the hardness and lubricity of

<sup>\*</sup> Esay XIX. page 238.

<sup>†</sup> See Esfay XXXII. page 355 feq.

# 472 LVI. Second Analysis of Lepidolite.

its fealy aggregate particles would allow, and digested it with a large quantity of muriatic acid, in a temperature raised at intervals to the point of ebullition. The remaining powder of the stone, when separated from the muriatic solution and washed, was desiccated and ignited. It still appeared, as before, in the form of white, very delicate shining scales, and weighed 210 grains. Treated with the blowpipe, it sufed, nearly as easily as lepidolite in the rough state, to a smooth globule.

- b) This circumstance making it evident that the muriatic acid had effected only an incomplete decomposition, I reduced again the remaining powder, by long continued trituration, to the most comminuted state possible, and boiled it once more with a fresh quantity of muriatic acid. The residue separated by siltration shewed now no farther disposition to melt, and seemed to consist of mere siliceous earth.
- c) The muriatic folutions (a) and (b) were then evaporated to dryness, in a fand-heat; the faline mass remaining was pulverized, covered with alkohol, and placed in a warm temperature. A confiderable sediment settled to the bottom; which, after the spirituous solution had been poured off, was dissolved in water, combined with some drops of ammoniac, and siltered. It then lest behind it a brownish slime, consisting of alumine, silex, and oxyd of manganese.
- d) I next evaporated the clear folution that had passed the filter. It lest behind a saline pellicle, consisting of small cubes; which, after gentle ignition, in order to drive off the small portion of muriated ammoniac existing in it, weighed 16½ grains. This salt was muriated pot-ash. Dissolved in a little water, and combined with a solution of pure tartareous acid, it formed acidulous tartrite of pot-ash,

(cream

(cream of tartar), which by combustion yielded carbonat of pot-ash.

Now, fince in 16½ grains of muriated pot-ash are contained 10 grains of pot-ash free from water and carbonic acid, there remain 4 grains of this last to be reckoned as constituent parts in 100 of lepidolite.

#### B.

- a) Two hundred and fifty grains of powdered lepidolite were exposed to a red-heat, during two hours, in a filver-crucible, previously mixed with the same quantity of very pure carbonated soda, that had effloresced in the air. This mixture came out of the fire a compactly united mass, of an uniform, lively brick-red. It was pulverized, and superfaturated with dilute muriatic acid, and kept in digestion till the red colour had totally vanished. The siliceous earth that subsided from this solution was afterwards separated by means of the filter.
- b) The muriatic folution was then evaporated to drynes; the faline mass was extracted, by alkohol, in a low heat; the sediment, left undissolved by this last, was redissolved in water, then combined with a little ammoniac, siltered, and again evaporated to a dry salt.
- c) The dry salt, thus obtained, was again dissolved in water, and, in combination with liquid acid of tartar, exposed to a warm temperature. At the beginning, the mixture continued clear; but, gradually, it deposited minute crystalline grains, which, after lixiviation and drying, weighed 12½ grains. They consisted of regenerated tartar, from which carbonated pot-ash was produced by combustion.

## 474 LVI. Second Analysis of Lepidolite.

d) I now returned to the precipitate, separated by means of ammoniac (b). This I dissolved in dilute sulphuric acid; and, after having added to this solution the spirituous solution of the muriated alumine (b), as well as the muriatic solution from which the regenerated tartar had been separated, I subjected the whole for some time to digestion; and finally freed it, by siltration, from the remaining brownish, muddy deposite. This solution, when farther evaporated, without any addition of acetated vegetable alkali, shot into regular crystals of alum, amounting to 185 grains. The remainder of it, still farther evaporated, congealed to a shapeless saline mass.

Thus, by the experiment B, the presence of the alkaline saline constituent part in lepidolite has received an additional proof: for, these 250 grains of this fossil yielded as much pot-ash as was necessary to the production of the 12½ grains of regenerated tartar, mentioned at (c), and likewise the quantity entering into the 185 grains of the crystallized alum here obtained.

However, the quantity of vegetable alkali naturally contained in lepidolite is more accurately shewn by the experiment A; according to which, as mentioned in its place (A.d), there must be added to its other constituent parts 4 per cent. of pot-ash.

Hundred parts of Lepidolite, therefore, contain:

Silex	54,50 38,25
Pot-ash	4 0,75
Lofs, partly confifting of water	97,50
	100

In my first analysis I noticed my surprise, that, in this very suffible stone, besides the silex and alumine, no conflituent part could be found to promote sussion, except the very trining portion of the oxyds of manganese and iron.

Yet I do not venture to affirm, unconditionally, that this fufibility of *lepidolite* is owing to this alkaline ingredient now discovered in it; because the *leucite*, whose earthy parts are likewise filex and alumine, as well as lepidolite, is, in fact, infusible, notwithstanding that it contains the alkaline ingredient in five times the quantity of that of lepidolite.

rance from planets, like she of a orea

#### LVII.

## CHEMICAL EXAMINATION

OF

## URANITE.

## FIRST SECTION\*.

1.) HE ancient philosophers, who considered our globe as the center of the material universe; and the sun, on the contrary, merely as a planet destined, like the others, to a periodical circumvolution round the earth, flattered themfelves that they had discovered a great mystery of Nature, in the agreement of the feven celeftial bodies, which they affumed for planets, with the feven metals known in those times. In consequence of the various hypotheses which they founded on this supposed mystery, they allotted to each metal a certain planet, by whose astral effluvia its generation and maturation were to be promoted. In like manner, they took from these planets their names and fymbols, to defignate the metals subordinated to them. But as the above number of metals has long fince been increased by later refearches; and as the discovery of new planets has not kept pace with that of metals, the metals newly found out have been deprived of the honour of receiving their names from planets, like the older ores. They, therefore, must be fatisfied with the name given them accidentally, and, in most instances, by the common miner.

<sup>\*</sup> Read in the Royal Academy of Sciences, at Berlin. See Memoire Chimique et Mineralogique fur l'Urane, in the Memoires de l'Academie Royal des Sciences, &c. Août, 1726, jusqu'à la fin de 1787. Berlin, 1792.

Of late, feventeen metallic substances have been acknowledged as distinct metals, each of a nature peculiar to itself. The design of this essay is to add one to that number, the chemical properties of which will be explained in the sequel\*.

2.) The particular fossil, by the decomposition of which I have discovered this new metallic substance, is the black, or pitch-blende (pseudo-galena of many) as it has been hitherto called. In the mean time, I shall continue to use that appellation, till, in the progress of this essay, the necessity of giving it a new name will be conspicuous. This fossil is found at foachimsthal in Bohemia, and at fohann Georgenstadt, in the metalliserous mountains of Saxony.

Only a few writers appear to have been formerly acquainted with this mineral. Wallerius and Brünich mention, indeed, under the head Argentiferous Ores of Zinc, the pitch-blende, and a black pitch-ore (Pecherz); but it does not appear that they meant by it, or even have known the above fossil from foachimsthal and fohann-Georgenstadt. Werner, to whom its fracture, hardness, and gravity, sufficiently indicated that it could not be a blende, has transferred it from the class of zinc-ores to that of the ores of iron, calling it Eisen-pecherz; though only ad interim, until its proper place should be ascertained by chemical analysis. A subsequent conjecture of his, that this fossil might, perhaps, contain the metallic radical of tungsten, or wolfram; was thought to be supported by actual experiments made at

<sup>\*</sup> Even this number (17) of [metallic substances has received an addition, by the *Titanium*, so lately discovered, as is shewn by Essay XIV. pages 200 and 210.

Schemnitz\*. But this pretended fact is contradicted by the refult of the following examination.

3.) The varieties of this fosfil, that have hitherto occurred, may be divided into two forts. The first of them is found in brownish-black, massive, and, for the most part, outwardly slat, reniform pieces. It is resplendent both externally and internally; wholly opake, and of an impersect conchoidal fracture. It is brittle, admits of being easily comminuted by trituration, and affords then a black powder, tending to the greenish. Its specific gravity, upon an average, is 7,500.

To this fort belong, in particular, the pitch-blendes dug at Joachimsthal, in the mines, or galleries; Sächsischer Edelleutstolln, and Hohe Tanne; where they are accompanied by brown-red ponderous spar.

The fecond variety, to which belongs the greatest part of pitch-blende that occurs at fohann-Georgenstadt, is greyish black, and exhibits various degradations, from the glittering to the dull or dim. At that place it is obtained in the mine Georg Wagsfort, in larger or smaller masses, between strata of schistose mica (Glimmerschiefer); which is nearly in a state of decay. It is usually accompanied by a metallic earth (oxyd), of a yellow, reddish, and light-brown colour; and, besides, also frequently by the green mica, as it is called, crystallized in small quadrangular tables. Sometimes it is observed to be invested by compact galena (Bleyschweif), or having this latter disseminated in its substance in delicate veins and points. It has also been met with there in the mine Neujabrsmaassen, between alternate strata of the sibrous brown iron-stone+.

<sup>\*</sup> See Bergmannisches Journal. 1789. Vol. I. page 612.

<sup>†</sup> A more ample description of its external properties has been given by Karsten, in the 4th vol. of the Beobacht. u. Entdeck. a. d. Naturkunde. Berlin, 1792, page 178.

- 4.) When pitch-blende is tried by itself, before the blowpipe, it undergoes no alteration, and is perfectly infufible. If mixed with foda, or borax, and placed in the fame fituation, it is converted into a grey, cloudy button, refembling fcoriæ. But with a neutral phosphat it produces a clear, green globule. If in these trials some minute metallic grains ever appear, they proceed from the lead interspersed in the fossil.
- 5. a) I exposed half an ounce of triturated pitch-blende to a strong red-heat, in a coated glass-retort. After cooling, I found that it had loft feven grains. A fmall portion of fulphuric acid has also passed over, and in the neck of the retort a little fulphur was observed to be sublimed.
- b) Another equal quantity of pitch-blende was roafted in open fire, that is, on a test under the mussle, until all its fulphur had volatilized. By this management it loft 20 grains. Upon this I kept it one hour longer in ignition, and observed that its weight had again increased eight grains.
- . (.) To examine the relations of pitch-blende to the fixed alkalis in the dry way, I triturated 1 ounce of it with one ounce of carbonated pot-ash, and urged the fire to the fufion of the mixture in the crucible. The mass poured out of the veffel was black-grey, compact, hard, and of a lamellar fracture. When ground, boiled with water, and filtered, the powder of the fossil remained on the paper with its former black colour, and also nearly with its original weight. The colourless fluid had merely an alkaline tafte, excepting only a flight indication of alkaline fulphuret (liver of sulphur); and when saturated with nitric acid, it deposited some slocculi of siliceous earth, weighing sour grains.

# 480 LVII. Chemical Examniation of Uranite.

By this infolubility of pitch-blende, in melting pot-ash, it was decided that it in no way belonged to the fossils which contain tungsten, or wolfram.

7.) I now proceeded to examine its habitudes with acids.

Dilute sulphuric acid was incapable of effecting a true solution; it only extracted from it a faint greenish tincture. Even concentrated sulphuric acid did not entirely dissolve this sossil: for, after ½ ounce of pitch-blende had been digested with one ounce of that acid, in a retort, the liquor being then again distilled off to dryness, and the residue softened with water, and siltered, its undissolved part still weighed three drachms: and likewise the black colour which it still preserved shewed that no perfect solution had taken place. The sluid that had passed over was sulphureous acid; and the solution filtered off from the residue had a green colour.

- 8). Nitric acid, on the contrary, produced a more complete decomposition of that fossil.
- a) Half an ounce of the greyish-black, dull pitch-blendz was digested, in a low-heat, with moderately strong nitric acid. It was attacked by the acid with an evolution of red nitrous vapours. I affused, by degrees, more of the acid, till the disappearance of the black colour of the fossil shewed that its decomposition was accomplished. The solution, when again diluted with water, was of a bright wine-yellow, variegated with the greenish. It lest on the paper a white-grey residue, weighing 16 grains upon desiccation. This took fire, when heated in an earthen pot, and burned with a sulphureous stame; losing thereby  $5\frac{1}{2}$  grains. The remaining  $10\frac{1}{2}$  grains consisted of silex; from which nitromuriatic acid still extracted some portion of iron.

- b) One half ounce of the blacker fort of pitch-blende, treated in the same manner with nitric acid, coagulated, upon solution, to a bright-green gelatinous consistence, in which some light grey-yellow particles lay dispersed. By dilution with water, and siltration, it left 26 grains of a reddish-grey residue, 6 grains of which were sulphur, and the remainder an earthy matter, impregnated with iron.
- c) When no pure, compact lumps can be had, the pitchblende, which is still embodied with its matrix, may also be employed for extraction with nitric acid. Twenty-four bunces of moderately strong nitric acid, affused upon 8 ounces of fragments of this impure pitch-blende, previously pulverized, attacked it with vehemence; the mixture became hot, and emitted red vapours. After digestion for some time, I diluted the folution with water, and filtered it. The gangue, or matrix of the shistose mica kind, existing in the fosfil, remained behind as a light-brown mud; which, after washing and deficcation, weighed 41 ounces, but lost one drachm more by burning off the fulphur which it contained. I concentrated the greenish-yellow folution, by distillation, from a retort; by which management nitrat of lead feparated, in white glanular crystals, amounting to 50 grains.
- g) By muriatic acid only an incomplete folution was produced.

But if this acid be mixed with one third part of the nitric, the nitro-muriatic acid arising from this combination effects a perfect folution.

Half an ounce of pitch-blende, mixed with two ounces of aqua regia, became hot, and was violently attacked by this folvent; at the same time that the mixture strongly effer-

I i

vesced, and the solution was almost entirely effected for the greatest part. When it had digested a while, it was diluted with water, and passed through the filter. Its residue weighed 13 grains; which, after the combustion of the sulphur, left nine grains of a siliceous matrix. The solution deposited muriat of lead, while cooling, in minute, white, needle-shaped crystals, which, by reduction, yielded a reguline bead of lead, of \(\frac{3}{4}\) grain. After some time, there appeared in the solution some beautiful, large, bright, greenishyellow crystals, in rhomboidal fix-sided tables.

vith the metallic principle which is the chief ingredient in pitch-blende, as well as with its chemical relations to other fubfrances, I performed various experiments with the nitric and nitro-muriatic folutions before mentioned.

At first I attempted to find whether a reduction of it would take place in the humid way. With this view, I filled two glasses with those solutions, immersing in the one some polished iron, and in the other a thin stick of zinc. But in neither case was any thing precipitated.

11.) Pruffiat of pot-ash threw down, from both these solutions, a deep-brown-red precipitate, resembling red sulphurated oxyd of antimony (Kerme's mineral.). This phenomenon is one of the most characteristic properties, by which this metallic substance is distinguished. It is true, copper likewise salls down, of a brown colour, if precipitated from acid menstrua by means of Prussian alkali; but then it appears rather more in the form of slocculi, of a woolly cohesion: whereas the former, on its precipitation, directly spreads, or dissuff through the whole volume of the sluid. Still more does the brown-red precipitate, obtained by precipitating the oxyd of molybdena from its muriatic

muriatic folution, by means of Prussian alkali, resemble that mentioned above. However, besides that the colour of this last is brighter, these two metallic substances are, in every other respect, so different, that they cannot easily be mistaken for each other.

If the pitch-blende, as is mostly the case, be accidentally accompanied by a portion of iron, the precipitate appears, at first, of a dirty black, but, after the separation of this, its colour is a purer brown.

- 12.) Sulphuret of ammoniac precipitates the metallic fubflance of pitch-blende, diffolved in acids, of a brown-yellow colour; in which case, the mixture is usually covered by a white-grey pellicle of a metallic lustre.
- 13.) By tincture of galls, or gallic acid, added to excess, only a slight quantity of a blackish precipitate is produced. But if the predominant part of the acid be neutralized by an alkali, a copious precipitation of a chocolate-brown ensues.
- 14.) All alkalis throw down the metallic portion from the acid folutions of pitch-blende, of a yellow colour. This affords another character peculiar to that metallic substance. The shades, or degradations of that yellow colour, are various, according to the degrees of purity of the fossil, and, likewise, according to the nature of the alkaline salt employed in the process.

The fixed alkalis promote the precipitation, in the most complete manner, if they are used in their caustic, or pure state. The precipitate is then commonly lemon-yellow; but it inclines more to the white, if carbonated alkali is employed as a precipitant.

15.) If more carbonated alkali be added than is required to faturate the acid, part of the metallic oxyd will be rediffolved; but it falls again down, of a lemon-yellow, by faturating the exceffive portion of the alkali. A fimilar re-diffolution, in carbonated fixed alkali, happens, when the yellow oxyd, recently precipitated and washed, while yet moist, is mixed with deliquesced pot-ash, and digested in a boiling heat. If, to the saffron-yellow solution, after separation of the undissolved residue, nitric acid is added, it throws down the dissolved part of a pale yellow colour.

On repeating this experiment with caustic lixivium, the colour of the metallic oxyd changed to a dark-brown. But this lixivium, being afterwards examined, was found to contain nothing of that oxyd. This circumstance serves to prove that it is not the alkali, but the carbonic acid combined with it, that contributes to effect the solution before noticed.

r6.) Somewhat different was the colour of the precipitate which I have obtained from the greenish nitric solution of the blacker variety of pitch-blende (8. b.), by means of caustic soda; for this inclined from the yellow to the green. This is not owing to a latent portion of copper in the soffil; as the precipitate gives neither colour nor taste to caustic ammoniac poured upon it.

17.) This yellow metallic oxyd readily diffolves in acids.

When treated with dilute fulphuric acid, gently warmed, it was foon diffolved, leaving only the portion of lead which still remained in it. The folution, duly evaporated, afforded a lemon-yellow metallic sulphat, crystallized in small accumulated columns.

- 18.) The folution of the yellow metallic oxyd in weak-ened nitric acid, and made to crystallize by evaporation, at first deposited a small quantity of nitrat of lead, and, afterwards, beautiful, clear, oblong, hexagonal tables, of a pleafing, light-greenish colour; some of which were  $\frac{3}{4}$  of an inch long, and  $\frac{1}{4}$  of an inch broad. To preserve these crystals in their original perfection, they must be kept in a closed vessel, as they seem liable to some decay by the access of air.
- 19.) The folution of this metallic oxyd, prepared by muriatic acid, evaporated to the point of crystallization, and left standing in the cold, at first yielded some muriated lead, in fine needles; but, after this, it shot into yellowish-green crystals, the fundamental figure of which appears to be the rhomboidal, or oblique quadrangular table.
- 20.) By diffilled vinegar, strengthened by freezing, this metallic calx was diffolved, with the aid of digestion. After gentle evaporation, this solution afforded fine, clear, topazyellow crystals, in regular, sour-sided, thin columns, with tetrahedral pointed terminations, some of them one inch long. When I subjected some of these crystals to ignition, beginning with a low heat, the metallic oxyd left, after the expulsion of the acetic acid, preserved the same sigure, for the most part, which the crystals had originally possessed.
- 21.) Phosphoric acid, likewise, is a solvent of the precipitate obtained from pitch-blende. But this solution does not long continue clear; the phosphated metallic oxyd falling down, by degrees, in yellow-white, amorphous floculi, of difficult solution in water. A similar precipitate also arises on pouring phosphoric acid into the acetic solution of this fossil.

- 22.) I introduced a mixture of one part of pitch-blende with three of nitre, by fuccessive portions, into a red-hot crucible. The mass foamed much; but only a weak detonation was observable. I kept it in ignition for half an hour, after which I set it aside to cool. It was of a chocolate-brown; and when this mass, liquisted with water, had been filtered, the powder of the fossil left on the paper remained of the same colour. The colourless lixivium contained still some undecomposed nitre; and acids caused it to deposite a whitish precipitate, which for the most part consisted of silex.
  - 23.) After these researches, I made some experiments relative to the process of reduction.—When the yellow metallic oxyd was tried upon charcoal before the blow-pipe, it exhibited the same phenomena as were mentioned of the crude pitch-blende, (4.); excepting that it acquired a brownish-grey colour by ignition; and that the brownish colour of the globule produced, on its treatment with soda and borax, was purer and clearer than that from the rough sossilisting from its mixture with an alkaline phosphat, in the like process, was more pure and clear.
  - 24.) The trials made by fusion in the crucible gave all exactly such results, as those previous small trials upon charcoal would allow me to expect.
    - a) One drachm of rough pitch-blende, mixed with 1½ drachm of calcined borax, together with fome charcoal-dust, and covered with muriat of soda; and
    - b) An equal quantity of rough pitch-blende, mingled with two parts of black flux, and a little muriat of foda, where melted, each separately, in the windfurnace

furnace with a firong fire. In both cases the fossil was converted into a black-grey, dim scoria, without any trace of reduction: only that some metallic grains of lead appeared, originating from the particles of that metal disseminated in the rough sossil.

- 25.) In the following experiments I employed the pure yellow precipitate before mentioned.
  - a) One drachm of it was mixed with two drachms of black flux, and inferted in a charcoal-crucible;
  - b) Another drachm was mingled with twice its weight of calcined borax, and likewife put in a crucible made of charcoal; and
  - c) A third drachm was mixed with 10 grains of charcoal-dust, 20 grains of calcined borax, and two drachms of powdered white glass.

These mixtures, the crucibles being first luted, were exposed for one hour and a half to the strongest heat of the melting furnace.

The product, which in all three crucibles was nearly the fame, confifted of a black vitreous fcoria, but exhibited no indication of any metallic button.

26.) Being thus convinced, that the reduction of this metallic oxyd, which I had in view, was not to be accomplished by means of faline and vitrifying substances, I resployed to treat it merely with combustible bodies, after the manner of the assays of manganese. For this purpose, I triturated 120 grains of the yellow metallic oxyd to a paste, with linseed-oil, and caused the oil gently to burn on a

T i 4

test. There remained 85 grains of a heavy black powder behind; which I exposed, in a well secured charcoal-crucible, to the medium heat of the procelain-furnace.

At the same time, another crucible, containing pure oxyd of manganese, and prepared in the same manner, was exposed to the same fire.

When both these crucibles were brought back from the furnace, I found, that, in the fecond, the reduction of manganese to the reguline, or metallic state, had been most perfectly accomplished. But in the first crucible I found the oxyd, obtained from pitch-blende, in the form of a heavy and only loosely coherent mass; which by friction between the fingers could be divided into a fine black-brown dust, yet possessed a metallic lustre.

In pouring nitric acid upon a part of that dust, the solution went on with pretty considerable energy; the mixture growing hot, and giving out a quantity of red nitrous sumes. By this phenomenon, I was persuaded, that the oxyd had in some manner been revived to the metallic state, although not run into one mass; and, hence, that this metallic substance is more refractory than even manganese.

27.) To experience, whether this oxyd of pitch-blende, thus far metallized, would not perhaps prove more fufible, I put the remaining portion in a charcoal-crucible; covering it with half its quantity of calcined borax, and the remaining fpace of the veffel with pulverized charcoal. The outer crucible of baked clay, into which the former was inferted, was then well luted, and exposed to the strongest heat of the porcelain-furnace. My expectation, as I found by the result, was not totally disappointed; for I now obtained a coherent mass, consisting of conglutinated extremely

tremely minute metallic grains, whose aggregation, however, was not compact, but finely porous, and like froth. The colour of that metallic mass was outwardly dark-grey, but inclining on the streak to the brownish. Its metallic lustre, for want of perfect density, was but moderate, and the cohesion of its integrant particles only slight. Its specisic gravity, 6,440.

No alteration was produced, when small portions of that regulus were ignited upon charcoal with the assistance of the blow-pipe. On fusing it with fusible phosphoric salt, the globule, while melting, was coated with a dull, silvery white pellicle, formed by cohering, exceedingly fine metallic globules. On continuing the fusion, this metallic crust entered deeply into the body of the globule, which at last acquired the appearance of a dim, grey-green, porous scoria.

- 28.) With the view of attempting an artificial mineralization by fulphur, I mixed the yellow oxyd with twice its weight of fulphur in a finall glafs-retort, and expelled again from it the greatest part of the fulphur, by applying heat. The residue combined with the rest of the sulphur was a black-brown, compact mass. But the degree of affinity of this metallic substance with sulphur is but low; for, on exposing again this sulphurated mass, in another retort, to the action of sire, the remainder of the sulphur admitted of being entirely driven out; while the metallic part remained behind in the form of a black, heavy, granular powder.
- 29.) To investigate what colour this metallic oxyd would give to glass-frits, and what effect it would produce on porcelain, when applied to it as an enamel colour, the following experiments were made.

- b) Silex . . . . 2 drachms,

  Mild foda . . . . 1 drachm,

  Yellow metallic oxyd . . 10 grains,

  yielded an opake, black-grey glass.
- Silex,
  Burnt borax, of each . 2 drachms,
  Yellow metallic oxyd . . 20 grains,
  afforded a glass perfectly resembling brown rock-crystal
  (Rauch-topaz).
  - d) Silex,

    Vitreous phosphoric acid,

    prepared from bones,

    Yellow metallic oxyd . . 20 grains,

gave a bright apple-green, opake glafs, almost like chryso-prafe.

from animal bones . . 2 drachms,
Yellow metallic oxyd . . 10 grains,

produced a clear emerald green glass.

These two last vitrifications, by degrees, attracted moisture from the atmosphere.

f) The yellow metallic oxyd, gently ignited, mixed with a proper flux, and applied to porcelain, and fused upon it

in

LVII. Chemical Examination of Uranite. 491 in the enamelling furnace, produced a faturated or deep orange-yellow colour.

30.) From the whole of these experiments it is manifest, that the pitch-blende does not belong either to the ores of zinc, or to those of iron, nor yet to the genus of tungsten or wolfram, and in general to none of the metallic substances hitherto known; but, on the contrary, that it consists of a peculiar, distinct, metallic substance. Therefore its former denominations, pitch-blende, pitch-iron-ore, &c. are no longer applicable, and must be supplied by another more appropriate name.—I have chosen that of uranite, (Uranium), as a kind of memorial, that the chemical discovery of this new metal happened in the period of the astronomical discovery of the new planet Uranus\*.

31.) In the pit Georg Wagsfort, at Johann-Georgenstadt, the metal uranium likewise occurs in the form of a metallic oxyd, of an earthy appearance. This is the earthy foffil, already mentioned at the beginning of this effay, which there accompanies the compact uranitic ore under various fhades of colour, passing from the pale sulphur-yellow into the brick-red, as also into the brown-yellow. The lightvellow and reddish varieties are the purest; since, when disfolved in nitric acid, and treated with Pruffian alkali, they immediately precipitate of a brown-red colour. The darker varieties, on the other hand, contain more or less of iron. This earthy oxyd of uranium has formerly been taken for an ochre of iron. It has likewise been considered, as the product arising from a previous decay of shistose mica, which forms the gangue, containing this fossil in the mine just mentioned.

<sup>\*</sup> This is called Georgium sidus in England only .- Trans.

- 32.) To this place likewise belongs the green mica, as it was formerly called, that is also dug from the same pit. This beautiful fossil is found in the fissures, rifts, and partings of the rock, as well as upon the earthy uranitic oxyd; for the most part, in the form of thin quadrilateral tables, some of which approach to the cubical figure. Its colour is variable, passing from the emerald green to that of the green-finch, to a lemon-yellow, and even to the silver-white.—It is also found on the Tannenbaum at Eibenstock, mostly upon brown hornstone-quarz, though but very sparingly.
- 33.) It is indeed certain, upon various grounds, that this fossil is not a true mica. Yet its nature continued to be a matter of question, until Bergmann, on analysing it, thought that he had discovered in it muriated copper and argil; and it was upon this authority that Werner has given it the name Chalcolite. Notwithstanding this, Bergmann still entertained some doubt concerning the result of his own experiments; especially as he could examine only a very small quantity of it.
- 34.) But according to my experiments, this green mica, or chalcolite, is a crystallized oxyd of uranium, coloured by copper. After having procured, with great trouble, and facrificing feveral specimens, a small quantity of exquisitely pure crystals, I poured upon them nitric acid, which dissolved them quietly, and entirely in the cold. Into one part of this solution I dropped nitrated silver; but no turbidness ensued, though Bergmann afferts that he has obtained muriat of silver. (Horn-silver).

Into another portion of the solution of the green crystals I introduced a polished steel-spring, and sound that it became incrusted with a coppery coating of metallic lustre.

The

The remainder of that folution was faturated with caustic ammoniac. A blueish-grey precipitate fell down, and the liquor, likewise, assumed a blue colour. I then added as much ammoniac, as was necessary to disfolve all the copper contained in that fluid; after which, I decanted the bright blue folution from the precipitate: affusing upon this last successive fresh portions of ammoniac, until this alkaline fluid was no longer tinged blue. The refidue, which had been thus freed from copper, I re-diffolved in nitric acid, dividing the folution into three parts. When a polished watch-spring had been immersed in the first, neither copper, nor any thing elfe was precipitated. By combining the second portion with Prussian alkali, a brown-red precipitate sufficiently copious was obtained. From the third portion, caustic pot-ash threw down a pure yellow oxyd of uranium.

Copper, however, should not be considered as an essential constituent part of the crystallized oxyd of uranium; since I have not sound the least trace of it in another variety, that had a pure wax-yellow colour.

## SECOND SECTION.

Another more pure variety of compact uranite, of a luftre almost metallic, which I afterwards received from foachimsthal, induced me to repeat its analysis.

#### A

a) Five hundred grains of this uranitic ore were powdered, and digested in a gentle heat, with nitric acid of a moderate strength. The quantity of the acid employed, not being sufficient to effect a total solution, the mixture appeared like a sluid, rendered turbid by a fine brick-red mud; but which disappeared on the addition of another small portion of nitric acid. The solution became clear, while a light-grey slocculent matter separated, and was of a greenish aspect. The residue collected by siltering weighed

30 grains after drying. When placed upon a test, gently heated, its fulphureous part was consumed with a faint slame; and the remainder proved upon trial to be mere filiceous earth, weighing 25 grains.

b) The nitric folution was in part generally evaporated. It deposited nitrat of lead; which, when re-dissolved in water, and combined with sulphuric acid, yielded 35 grains of sulphated lead. These indicate almost exactly 25 grains of metallic lead.

After this separation of the lead, the nitric solution gradually shot into longish hexahedral plates of a light-yellow colour, somewhat inclining to the green. This nitrat of uranium, re-dissolved in water, and treated with caustic pot-ash, afforded 440 grains of yellow precipitate.

c) The remainder of the folution, that would no longer crystallize, when tried by Prussian alkali, shewed by the blue colour of its precipitate, that it had been contaminated with iron. This precipitate was then inpissated, driving out the nitric acid by means of heat; after which it left a residue weighing 40 grains. This last, when boiled again with nitric acid, and siltered, left on the paper a red oxyd of iron; which, triturated with linseed-oil, and ignited, obeyed the magnet, and weighed 13 grains.

Since, therefore, an bundred parts of this ore contain no more than one part of fulphur, and, on the other hand, five parts of lead; there remains no doubt, but that this small quantity of sulphur belongs to the lead existing in the ore. For this reason, I no longer consider the black uranitic ore, including its varieties, and taken by itself, as an ore mineralized by sulphur, but as an imperfect metallic oxyd; that is to say, combined with but little oxygen. This condition, so nearly approaching the metallic state, is the cause why the solution of this oxyd in nitric acid is attended with extrication of heat and nitrous vapours.

Hence,

Hence, according to what has been faid, the shining black ore of uranium from foachimsthal is composed, in one hundred parts, of:

Sulphat of lead		6
Silex		5
Oxyd of iron, attractible by the magnet		2,50
URANIUM		86,50
errential transfer and a contract of	-	100

#### B.

With the yellow oxyd, that had been precipitated from the folution of the uranitic nitrat, freed from iron, (A. 6.) I inflituted feveral experiments, with a view of its reduction. These, however, did not completely answer my defire, to obtain a pure metallic button, run into a compact mass. Of those experiments, the following is that which has best succeeded.

Fifty grains of this oxyd, when ignited, were formed with wax into a ball, and in a well-closed charcoal crucible exposed to the most vehement heat of the porcelain-surnace, the intensity of which gave 170 degrees in Wedgwood's pyrometer. The metallic button obtained weighed 28 grains, and presented a dark-grey, hard, firmly cohering, sinely-grained, of very minute pores, and, outwardly, glittering mass. On rasping this with the sile, or rubbing it with another hard body, the metallic lustre appeared on the place, thus laid bare, of an iron-grey colour; whereas in the other assays that were less perfect, the streak of the uranitic regulus is usually more verging to the brownish. This metallic button likewise surpassed in specific gravity those before obtained; being, 8,100.

[ 496 ]

### LVIII.

## CHEMICAL EXAMINATION

OF TWO NEWLY DISCOVERED

## TITANITES.

THE discovery of *Titanium*, in the red Hungarian shorls, and in the small hair-brown crystals, from the country about Passaut, having so much excited the attention of Chemists and Mineralogists, it was natural to expect, that this new metallic substance would also be found in other places. The event has shewn, that this expectation was not ill founded.

The chemical analysis made at Paris by Vauquelin and Hecht, with a fossil, discovered by Miché and Cordier at St. Yrieux, in the department of Haute-Vienne, has shewn, that this metallic substance is likewise a native of France 1.

To this the present essay affords a new addition, by giving the analysis of two other titanites, but lately discovered.

## FIRST SECTION.

Titanite from Spain.

I HAD the pleasure of receiving from the collection of Baron Racknitz at Dresden, which is particularly rich in

<sup>\*</sup> See Essay XIV. page, 200.

<sup>†</sup> Esfay XV. page 211.

<sup>1</sup> Journal des Mines. Paris. No. XV. page 10.

Spanish minerals, a fossil whose outward characters justified the suspicion, that it might be an ore of Titanium.

It occurs at Cajuelo, near Vuitrago, in the province of Burgos.

The internal colour of it is a light reddish-brown, inclining in some places to the copper-red; but externally it is coated with white clay. It seems to have the form of a hexahedral column, with a flat six-sided pyramidal termination; but instead of the actual point, it has a regular excavation, which resembles an inverted, hollowed, hexahedral pyramid. In the inside, that soffil has a strong semi-metallic lustre. Its cross-fracture is very distinctly straight lamellar; and its longitudinal fracture impersectly and small conchoidal. It is very little transparent on the edges; brittle, very hard, and of dissicult levigation, by which it affords a greyish-brown powder. The specific gravity of it is = 4,180.

One hundred grains of it, finely ground, and mingled with 600 grains of mild pot-ash, were brought to sustion in a crucible. The melted mass was of a pearly-grey, which, upon re-dissolution in hot water, deposited the oxyd of titanium of a perfectly white colour. When this had been siltered off from the colourless alkaline sluid, and lixiviated with water, till the washings no farther indicated any trace of alkali, it was desiccated, and sound to weigh 175 grains.

This titanic oxyd readily dissolved in muriatic acid, and was precipitated from it of a permanent green, by Prussian alkali, and of a lively brown-red, by gallic acid; and in general, in all its other properties, it agreed with the white exyd of titanium, extracted from the red Hungarian short.

## SECOND SECTION.

Titanite from Aschaffenburg.

WITH the foregoing titanite from Spain another fosfil corresponds, which Prince Dimitri Gallitzin has found several years past not far from Aschaffenburg, in the Spessart forest, preserved in his collection as a mineral not yet ascertained.

Its interior colour is a deep reddish-brown; externally it passes somewhat into the lead-grey, and exhibits silver-white scales of mica adhering to it. The specimen, here examined, was a rounded prismatic, and, as it appeared, a sour-sided crystal; the alternate angles of whose facets seemed to be obtuse, and the ends apparently not yet completely crystallized. Its fracture exhibits a strong semi-metallic splendour. The longitudinal fracture is straight soliated; the cross fracture, impersectly conchoidal. It is untransparent, brittle, and very hard. Its specific gravity was sound to be 4,055.

One hundred grains of this titanite were finely powdered, and fused with 600 grains of carbonated pot-ash. The mass, when fixed by cooling, presented a greenish surface, and a pearly grey fracture. Upon pulverization, and solution in water, the filtered alkaline liquor was likewise greenish, but soon lost its colour. The lixiviated and dried oxyd of titanium weighed 166 grains. Its white colour had, a little of a reddish tinge, arising, perhaps, from a small portion of manganese; the traces of which were shewn by the external greenish colour of the melted mass, as well as afterwards by that of the alkaline liquor.

As for the rest, the metallic oxyd obtained from this fossil of Aschaffenburg exhibited in every respect the same habitudes or relations, as the preceding from Spain, or that which had been separated from the Hungarian titanite.

LIX.

#### LIX.

### CHEMICAL EXAMINATION

OF SOME

### FERRUGINOUS TITANITES.

## FIRST SECTION.

Iron-shot Titanite from Cornwall.

WITHIN a few years a fossil has been brought into notice by the name Menachanite, which has been found in the parish of Menachan, in Cornwall, and consists of grey-black, fand-like grains, obeying the magnet. Mr. M. Gregor, of Menachan, who dedicates his study to mineralogical chemistry, has given not only the first information of this fossil, but also a full narrative of his chemical researches concerning it. The chief result of these is, that menachanite has for its constituent parts iron, and a peculiar metallic oxyd of an unknown nature\*.

By the following examination it will appear, that this fubstance, which, besides iron, forms the second chief component principle of menachanite, is precisely the very same which constitutes the Hungarian red shörl; namely, oxyd of titanium. With this opinion also, most of the phenomena, noted down by Mc Gregor, in his operations with menachanite, agree.

<sup>\*</sup> Crell's Chemische Annalen. 1791. vol. I. pages 40 and 103.

K k 2 Though

Though I was eafily convinced of this fact by my own experiments, it feemed, on the other hand, very difficult to feparate entirely the iron from the titanic oxyd; and, hence, to afcertain the true proportion of these two ingredients to each other. Passing over various experiments which I made with this design, I will relate only the two following, by which I obtained the oxyd of titanium, freed the most from iron.

#### A.

- a) Two hundred grains of menachanite, finely powdered, were mixed with ten times their quantity of a lixivium, composed of equal parts of caustic pot-ash and water. This mixture, being inpissated to dryness in a polished iron-pot, lodged in a sand-bath, was afterwards ignited in open fire. The mass ran into thick sussion, and assumed in cooling a dirty dark-green colour.
- b) By dilution with water, it gave a greenish folution, from which a dark cinnamon-brown powder subsided, which, detained on the filter, edulcorated, and dried, appeared very loose, and weighed 374 grains.
- c) The green alkaline fluid foon lost its colour, and depofited fome brown flakes, which upon trial were found to be an impure oxyd of manganese, and weighed half a grain. When this liquor had been treated with an over-proportion of muriatic acid, and again neutralized with carbonated potash, it afforded a whitish precipitate, which afterwards was decomposed into seven grains of ignited silex, and two grains of oxyd of titanium.
- d) The 374 grains of brown-powder (b) were mixed with fix ounces of muriat of ammoniac, and fublimed in a retort.

retort. The fal-ammoniac volatilized of a strong yellow. The residue had the form of a loose, isabella-yellow powder, and was found to be still contaminated with iron. When freed from this metal by previous lixiviation with water, and subsequent digestion with muriatic acid, it was of a grey-white, after a repeated washing and drying, and amounted to 168 grains.

- e) This grey-white metallic oxyd, proving infoluble in acids, was fused in a crucible with five times its quantity of carbonated pot-ash, and poured out. After congelation, the saline mass presented a pearly white; was compact, and of a coarse-striated fracture. On triturating, and washing it with water, the metallic oxyd was lest behind of a perfectly white colour. This, when edulcorated and dried, weighed 276 grains, and shewed itself in every respect to be a completely pure oxyd of titanium.
- f) To obtain the iron, I diffolved in water the fublimed muriat of ammoniac (d), mixed the folution with the water employed for edulcorating the refidue, which thereby became muriated, and then I faturated the whole with caustic ammoniac. The brown oxyd of iron, thus separated, was dried, drenched with linseed-oil, and heated to redness. It weighed 100 grains, and was rapidly and entirely attracted by the magnet.

#### B.

I effected another complete decomposition of menachanite in the following shorter way.

a) Two bundred grains of menachanite were prepared for their decomposition in the same manner as explained before at (A. a, and b); and the light-brown powder, thus obtained, was ignited for half an hour in a crucible. It now K k 3

received a blackish chocolate-brown colour, and weighed 260 grains.

- b) After having affused upon it three ounces of muriatic acid, I evaporated it in a porcelain vessel to a moderately desiccated mass; the colour of which was yellow, like the yolk of eggs, and mixed with orange-yellow. It was then diluted with water, and put on the filter. The filtered liquor contained muriated iron, and the washed residue exhibited on the paper a fine, heavy powder, of an isabella-yellow, which, dried in a low-heat, weighed 106 grains.
- c) I mixed this with a quintuple portion of carbonated pot-ash, and brought it into sussion in a crucible. The mass, when poured out, and fixed by refrigeration, was of a pearl-grey, with some light-brownish spots. Upon triturating, and edulcorating it with water, the titanic oxyd remained behind as a slocculent, yellowish-white powder, amounting to 226 grains, when desiccated in the air.
- d) This oxyd readily dissolved in muriatic acid, and entirely, without leaving any residue. However, it was not perfectly free from iron; since the precipitate produced from it by the insusion of galls did not exhibit that deep-yellow-red-colour, which is peculiar to the pure gallated oxyd of titanium. On this account, I caused the solution to boil upon a sand-heat; by which management the titanic oxyd separated from the liquor in the form of white gelatinous slocculi. It was then collected on the filter, and lixiviated with water, until this last was no longer blackened by gallic acid.
- c) The titanic oxyd, again deficcated, appeared now of a bright yellow colour, and was not attacked by acids in its prefent state. To render it again soluble, I ignited, and urged

urged it by heat to fusion, with five times its quantity of carbonat of pot-ash. The pearl-grey mass, then produced, and softened by warm water, deposited the metallic oxyd of a perfectly white colour, weighing 230 grains, after edulcoration and drying. Muriatic acid readily dissolved this oxyd, which now, upon trial, appeared to be pure oxyd of titanium, absolutely free from all iron.

f) The fluids, that held the muriated iron in solution, were combined with caustic ammoniac; and the oxyd of iron precipitated by that means, when moistened with linseed-oil, and ignited, was found to weigh 102 grains.

With regard to the proportion of titanium to iron in menachanite, it cannot be determined in the direct way. The reason of this is, that the weight of the separated oxyd of titanium varies very much, according to the different degrees of saturation with oxygen, and perhaps also with carbonic acid; and moreover, according to the degree of desiccation, &c. With greater certainty may the state of the iron contained in menachanite be determined; which seemingly agrees with that of Ethiops martial, or black oxyd of iron, attractible by the magnet. Allowing this, the constituent parts of Menachanite in the hundred may be assumed as follows:

Oxyd of iron, attract	ible by th	e magne	t.	51
Oxyd of titanium .		6 -		45,25
Silex				3,50
Oxyd of manganese				0,25
		in an	10 10 3	100
The second second	C.			

In order to become acquainted with the habitudes of menachanite in fire, I subjected it to the following experiments.

K k 4 a) Exposed

- a) Exposed in a charcoal-crucible to the fire of the porcelain-furnace, it proved infusible. Its grains were rendered fomewhat more porous; its black colour had become paler, and its lustre less brilliant. At the same time its surface was found overlaid with minute grains of iron.
- b) But in the clay-crucible, the menachanite entered into perfect fusion, and in this state was imbibed by the pores of the vessel; the places of which, that had been penetrated by the melted fossil, were externally brown, but in the fracture black and resplendent.

### SECOND SECTION.

Ferruginous Titanite from Aschaffenburg.

MENACHANITE is not the only instance of a fossil composed of the oxyds of iron and titanium. Besides that from Cornwall, fimilar mixtures occur in various countries, differing only in the proportions of their respective ingredients. A proof of this is afforded by the following examination of a fosfil, which Prince Dimitri Gallitzin has likewise found in the Spessart forest, near Aschaffenburg, together with the pure titanite described and examined in the preceding fection. The specimens given me for the sake of this enquiry, by that zealous promoter of mineralogical science, are of various fizes; the largest is two inches long, one inch broad, and half an inch high. Most of them are free from the veinstone, or matrix; but some are embodied in a grey, flat-conchoidal quarz (Fettquarz). Their colour is iron-black, accompanied outwardly by a moderate, but inwardly by a stronger, metallic lustre. The fossil itself is compact and opake. Its fracture is uneven, and of a fine grain; its fragments indeterminately angular. It is very brittle, hard, and is only with difficulty ground to a fubtle powder

powder, which has a black colour. Its specific gravity is 4,740.

By the magnet this fosfil is not in the least attracted, not even its smallest splinters; nor does it itself attract the least particle of iron. The more remarkable is it, therefore, that it is possessed of the property of indicating, like the loadstone, the adverse poles, by contrarily attracting and repelling either end of the poles of the magnetic needle, or any moveable magnetic bar.

- a) One hundred grains of the fossil, finely pulverized, were boiled down to dryness upon a sand-bath, in a polished iron-crucible, with two ounces of alkaline lye, one half of which consisted of caustic alkali. The vessel was then placed between burning charcoal, urging the heat to the ignition of the mass; whereby it sufed with the consistence of a thick syrup. The refrigerated mass was of a dirty brownish hue. On being softened with water, its undisfolved part subsided as an incoherent, reddish-brown powder, weighing 144 grains, after washing and desiccation. The alkaline liquor was destitute of colour, and had taken up nothing of the fossil.
- b) Upon these 144 grains a sufficient quantity of muriatic acid was poured, and again evaporated from it nearly to dryness. On diluting this combination with water, an isabella-yellow precipitate fell down from it. This last, collected on the filter, edulcorated, and dried, and then heated to sussing the times its quantity of carbonated pot-ash, yielded a grey-white mass, from which, after dilution with water, I obtained a yellowish-white powder, which, cleared by washing from the saline particles, and desiccated, weighed 45 grains. It also, when accurately examined, shewed evidently, that it was oxyd of titanjum.

c) The portion of iron, suspended in the muriatic solution, was precipitated by caustic ammoniac, and, when collected, it was moistened with linseed-oil, and subjected to a low red-heat. This iron weighed 78 grains, and the whole of it obeyed the magnet.

As, therefore, no other constituent part existed in the foffil, I may fairly consider the remaining part as its titanic portion. According to which, an bundred parts of the foffil contain:

### THIRD SECTION.

Ferruginous Titanite from Ohlápián.

#### A.

At the works at Ohlapian, in Transylvania, where auriferous sands are washed, there occurs a titanite mixed with less iron. It consists of compressed, or slat, rounded grains, for the most part of the size of a lentil, in which, now and then, slight traces of a destroyed crystalline form are observable. Its colour is greyish-black, inclining to the brownish-red. It is opake; externally of a middling, internally of a brighter, metallic lustre; of a lamellar texture; very hard, brittle; and reducible, by grinding, to a greyish-brown powder. Its specific gravity is 4,445.

If heated alone before the blow-pipe, it suffers no sensible alteration. Nor does the magnet shew any action upon this fossil, either in the rough state, or roasted.

This

This fossil is one of the mingled heterogeneous parts constituting the auriferous sands at Ohlápián, which consist of very unequal grains, as well with regard to their shape or form as to their bulk. Of these accumulated sands, the larger grains consist, for the greatest part, of this titanic ore.

The middle-fized grains are partly light-crimson, partly carmine-red. They are opake, and have half a line, (24 of an inch) in diameter. They bear great resemblance to spinell, or, on account of their conchoidal fracture, to the ruby, or red sapphire.

The smallest of them, which seem to be grains of quarz, are yellowish-white, very transparent, or semi-pellucid, acute angular, and in their diameter hardly  $7\frac{1}{2}$  part of an inch wide.

Of this last fize there exist also many fine black grains in the general mass, which probably are likewise titanium.

These, and the granular quarz, constitute by far the greatest part of the whole. The mingled heap, from one sixth to one fourth part, consists of the red grains; but the larger titanic grains lie but sparingly distributed among them.

a) Two hundred grains (by weight) of these minute titanites, previously pulverized, were mixed with a lixivium made of 600 grains of caustic pot-ash in a silver vessel, and after being evaporated to dryness, gently ignited for half an hour. This mass came out of the fire of a verdigris colour, with brown-red speckles. When diffused in water, and passed through the filter, it lest on the paper a loose, bright, and brown-red powder. The siltered alkaline li-

quor had at first a deep-green colour, but which soon disappeared; and it deposited oxyd of manganese, weighing four grains after ignition. When this precipitate had been removed, I faturated the fluid with muriatic acid, which threw down a whitish precipitate, turning yellow upon deficcation, and confisting of oxyd of titanium.

- b) This brown-reddish powder I boiled in a sand-heat with muriatic acid, evaporating it afterwards nearly to drynefs. By this treatment the mass assumed a yellow colour, like the yolk of eggs. It was in the next place diluted with water, and the white oxyd of titanium, separating from the fluid, was collected on the filter.
- c) This oxyd, being lixiviated and deficcated, together with the titanic oxyd obtained at (a), was mixed and fused in a porcelain-veffel with fix times their weight of carbonated pot-ash. This united mass, when re-dissolved in hot water, deposited a very white, pure oxyd of titanium, now foluble in all acids; which in this state of purity, and after washing and exficcation, amounted to 275 grains.
- d) Caustic ammoniac precipitated the oxyd of iron, that was held in folution by the muriatic fluid (b). This being collected, washed, and exposed, with some linfeed-oil, to a gentle red-heat, was found to weigh 28 grains.

On calculating by the method noticed in treating of menachanite, it appears that an hundred parts of this fossit from Oblapian confift of:

			100
Oxyd of m	anganese	 	. 2
Oxyd of ir	on		. 14
Oxyd of ti	tanium,.	 	. 84

B.

By this difference discovered in those three fossils, with respect to the proportion of their two chief constituent parts to each other, their classification in the mineralogical system is rendered somewhat difficult.—If the predominant constituent parts be assumed as the basis of a mineralogical arrangement, the fossil from Ohlapian will take its place as a species of the titanium genus, under the name of sidero-titanium; but the menachanite, together with the fossil from the Spesart, would constitute a new species belonging to the genus of iron, and obtain the denomination of titano-siderum.

To conclude: as, besides in the fossils here treated of, I have discovered in various others, of the genus of iron, some traces of this new metallic substance (as, for example, in the small magnetic iron-grains from Ceylon, which are often found there in considerable quantity, on washing the collected hyacinth, and other small loose fragments of gems), it is necessary, that for the future, in the more accurate examinations of the iron stones and ores of iron, regard should also be had to titanium, as one of their possible ingredients.

#### LX.

### CHEMICAL EXAMINATION

OF THE

# GARNET-SHAPED ORE of Manganese.

IN the granitic rocks of the Spefsart, near Aschaffenburg, whose chief aggregate parts are coarse-granular sel-spar, most frequently of a slessh-red, grey-quarz, and a little silvery-white mica; there likewise sometimes occur, as accessary ingredients, some black prismatic shorts, but, still seldomer, a sossil, hitherto unknown; the analysis of which I have made the subject of the present essay, and which, in the mean time, I designate by the name of garnet-shaped ore of manganese.

The merit of its discovery belongs to Prince Dimitri Gallitzin; and that of the description of its external characters, here subjoined, to Mr. Karsten.

- "The varieties of this fossil most recently collected pos-
- " fess a deep-hyacinthine red colour, which, in some, changes
- " to the reddish, or yellowish-brown; and some burst pieces,
- " that appear to have already fuffered some decay, are in-
- " wardly spotted greenish.
- . " Their form of crystallization is not quite distinct; no
- " perfect crystals having been yet found. But to judge
- " from the fragments inspected, as well as from the casts,
- " (the originals of which exist in the cabinet of Prince
- " Gallitzin), their leading figure feems to be a double eight" fided .

# Of the Garnet-shaped Ore of Manganese. 511

- " fided pyramid, sharpened off on both ends with four sur" faces. This pointed termination is more flat, and all
- " the angles are more rhombic, than in the garnet. Their
- edges are partly without truncation, and partly in a re-
- " versed order; so that two and two joined to each other
- " have their faces formed by the truncation, but the third
- " remains entire. Those crystals are in part of a middling
- " fize, in part fmall, and very fmall, all of them imbedded
- " in granite.
- " Externally they are finely, and, as it seems, alternately friated.
- "At the same time they are shining. The smallest va-
- " rieties alone, in which the striæ almost entirely escape
- observation, are strongly resplendent, of a lustre between
- the gloss of fat and the brilliancy of the diamond.
- "Internally, (where the fosfil is undecayed) it is throughut very resplendent, of a fine diamond lustre.
- "Its fracture is in two directions; namely, those which
- correspond with the striæ, straight-laminated; but in all
- " other directions, making an angle with the striæ, fmall
- conchoidal.
- "The fragments appear to be angular, of an indefinite form.
- "In those specimens which I have before me, I do not perceive detached or insulated pieces.
- "The fossil is also strongly transparent, more or less, on the edges.

cc Semi-

# 512 LX. Analysis of the Garnet-shaped

- Semi-indurated, in a higher degree than pitchftone;
- Wery brittle; and not particularly heavy.
- "Its specific gravity, at a mean ratio, I have found to be 3,600."

### A.

- a) Ignited by itself upon charcoal, this fossil is by degrees converted into a round greenish-black globule.
- b) By borax it is gradually diffolved into a clear olive-green pearl.
- c) Neutral phosphoric salt acts upon it only in a languid and imperfect manner, and forms with it by solution a very rifty globule, of a faint amethystine tinge. If nitre be projected upon it, while red-hot, the salt remaining upon the charcoal, after detonation, acquires some deep amethyst-red spots.

#### B. -

a) Hundred grains yielded, by grinding to fineness, a reddish-yellow powder. This was covered with a lye containing 300 grains of carbonated pot-ash; and when previously inspissated to dryness, it was subjected to red-heat. The ignited deep-green mass, disfused in water and filtered, afforded a lixivium of the same colour. By saturating it with nitric acid, its green colour was changed to a red. When exposed to a warm temperature, all its colour disappeared, and the sluid deposited brown slocculi, which, collected, weighed 4½ grains.

- b) The lixiviated refidue was of a deep black-brown, and weighed, upon deficcation, 141 grains. Nitric acid, with which it was digested, she wed by itself alone no solvent power upon it; but attacked it only when I added sugar to the mixture. The black-brown colour of the mixture disappeared; and from the solution, now become clear, solvent sugarth separated, amounting to 35 grains, upon edulcoration and red-heat.
- c) To the clear, bright-yellow, nitric folution, caustic ammoniac was added to excess of faturation. A light-brown precipitate ensued. The remaining colourless sluid, reduced by evaporation to a smaller volume, continued unchanged, on combining it with carbonated pot-ash.
- d) I re-diffolved this precipitate (c) in muriatic acid, and treated the folution, first with less caustic pot-ash than was required to neutralize the little predominant portion of uncombined acid. Upon this, I added to it a folution of 400 grains of tartrite of pot-ash (tartarus tartarisatus), which produced a copious, straw-yellow precipitate, in fine grains. The whole mixture was again evaporated to dryness, then strongly ignited in a porcelain-crucible, and the black-brown residue was lixiviated with a sufficient quantity of water.

This refidue, when dried again, together with the preceding, of  $4\frac{\pi}{2}$  grains (a), was once more ignited. It then appeared in the character of a fine oxyd of manganese, and weighed 49 grains.

I digefted once more this manganefian oxyd with nitric acid, adding fucceffive portions of fugar, and, lastly, diluting the mixture with water, and filtering it. On the paper there remained oxyd of iron, which, edulcorated, and heated

# 514 LX. Analysis of the Garnet-shaped, &c.

to redness, weighed 14 grains; and, after a second ignition with wax, was quickly attracted by the magnet. By deducting this, there remain, therefore, 35 grains for the oxyd of manganese.

f) The water employed to lixiviate the ignited mass (d) exhibited now a colourless alkaline solution. When sully neutralized with muriatic acid, and treated with carbonat of soda, a white, loose earth was precipitated, which, edulcorated and ignited, weighed  $14\frac{1}{2}$  grains. This earth, dissolved in sulphuric acid, and, when made to crystallize by proper management, afforded, throughout the process, crystals of alum.

Wherefore, bundred parts of this garnet-shaped ore of manganese have yielded:

					98,25	-
Alumine			f)		14,25	
Silex .						
Oxyd of ire	m .		e)		14	
Oxyd of me	angar	nese	e)	•	35	

#### LXI.

### CHEMICAL EXAMINATION

OF THE

## NATIVE OXYD OF TIN.

(Tin-stone. Zinnstein).

### FIRST SECTION.

Experiments in the dry way.

THE assay of tin, or the process of producing metallic tin in the dry way, by reviving a small quantity from the tin-ore, (called Tin-stone) or the native oxyd of tin, with the least possible loss of weight, has hitherto been subject to many difficulties. I have always obtained unequal, and hence uncertain results, in the repeated experiments, which I have made, according to the directions given in the elementary treatises on Docimasy, or Art of assaying Metals; that is to say, by combining the tin-ores to be assayed with fixed alkalis, with borax, and the like. The cause of this failure chiefly depends on the solubility of the oxyd of tin in the alkaline additions, employed as sluxes in the process.

On the contrary, the following affays, performed in the fimplest manner, without any addition, and merely in charcoal-crucibles, have always given me much more certain, and, on repeating them, constant results, with the exception of an inconsiderable difference.

L1 2

A.

#### A.

# Affays in charcoal-crucibles.

- 1.) Brown, crystallized tin-stone (Zinngraupen) from Schlackenwalde, in Bohemia, of the specific gravity of 6,760. One hundred grains of this, in entire pieces, were introduced into the cavity of a charcoal-crucible, closing its orifice with a stopper of the same materials. This charcoal-crucible was then tightly inserted and sastened in another of baked clay, placed upon the forge-hearth before the nozzle of the bellows, and the contents of the first, reduced to the reguline state, by directing thither a brisk current of air for half an hour. The metallic button of tin produced was a little blackish on its sides, and its surface coated with a greenish crust. It weighed 72½ grains.
- 2.) Light-brown, acicularly crystallized tin-stone (Needletin) from Polgooth, in Cornwall.

The prefent differs from the many other varieties of Cornish tin-stones in this, that it is an aggregate of very minute, for the most part capillary, four-sided columnar crystals, of a light-brown colour, and vivid lustre. Where the accumulation does not pass into compact tin-stone, the small interstices are filled up by chlorite.

The specific gravity of this oxyd of tin, in crude lumps, is 5,845; but when in the state of picked and well washed ore (Schlich), it is 6,750.

Hundred grains of this washed needle-tin, reduced in the charcoal-crucible, in the same manner as the foregoing, afforded a button of metallic tin, weighing 77 grains, with some

fome fuperincumbent fcoriaceous globules; which weighed two grains, and were probably fome remnants of chloritic earth.

- 3.) Crystallized grey tin-stone, having some white transparent spots, from St. Agnes, in Cornwall. The specific gravity of these crystals is 6,840. One hundred grains, treated in the same manner, yielded 74 grains of revived tin.
- 4.) Stream-tin (Seifenzinnstein) from Ladock, in Corn-wall. One hundred grains of this ore, confisting of loose blackish grains, and of the specific gravity of 6,560, were reduced in this way to 76 grains of reguline tin.

## 5.) Stream-tin, from Alternon, in Cornwall.

The colour of this, which must be reckoned among the purest tin-ores, is in some places darker, in others lighter. Of all the tin-stones, which I have weighed on the hydrostatic-balance, I have sound the present the most ponderous; its specific gravity being 6,970.

The reduced, or metallic tin, obtained from bundred grains of this ore, weighed 76 grains.

## 6.) Wood-tin, from Cornwall.

50 -61

This remarkable species, which till now is only known in shivery loose fragments, or ratchill of the miners (Geschieben), occurs in the washing works of tin, in the neighbourhood of St. Colomb, Roach, and St. Denis, in Cornwall; but in small quantities only. Usually the pieces are but small; those that have the size of a bean belong to the scarcer ones\*.

<sup>\*</sup> A specimen of wood-tin, of the scarcest magnitude, exists in the exquisitely sine collection of Baron Racknitz, at Dresden. It is two inches long, and one broad.

This ore, the only one of its kind, is externally diffinguished from the common tin-stones, chiesly by the total absence of any crystalline form; while, on the other hand, it exhibits its peculiar, bundled or fascicular fracture. Its external characters have been fully described by Werner\* and Karsten, chiesly.

I found the specific gravity of wood-tin-stone to be 6,450.

One hundred grains of it, reduced in the manner already mentioned, viz. fimply in the charcoal-crucible, gave 73 grains of reguline tin.

By the same method, I have subjected to the process of reduction various other tin-stones, as well as washed and pounded tin-ores, and have constantly obtained, in the result, from 72 to 77 per cent of reguline tin. The small portion of iron, commonly contained in tin-stones, usually sticks to the surface of the reduced tin, in very minute grains; and it is owing to this, that the button of tin is moved when the magnetic needle is approached to this part of its surface.

It is worth remarking, that usually small cavities are formed in the button of revived tin, as it cools and becomes fixed; which small fissures are covered by minute lamellæ, that, in colour and brillancy, resemble polished gold in a very illustive manner.

† Ibidem, vol. IV. 1792, page 397.

<sup>\*</sup> Beobach. u. Entdeck. a. d. Naturkunde. vol. I. Berlin, 1787, page 152.

B.

# Habitudes of Tin-stone, when exposed to heat in a crucible made of clay.

- 1.) Brown-tin-stone from Schlackenwalde, exposed to a porcelain-fire, in a baked clay-crucible, ran into a clear dense glass, greenish-grey in the middle, but of a bright yellow on the sides, and at top. The surface was invested with a dull whitish crust. The interior sides of the vessel were glazed of a milk-white, and overlaid with many small groups of light-brown, tender, needle-shaped crystals. The inner surface of the crubible lid, had also similar detached crystals adhering to it.
- 2.) Needle-tin from Polgooth, subjected in a clay-crucible to the heat of the porcelain-furnace, likewise produced a compact, light-brownish, transparent glass; covered on the upper surface with a brownish, dim, and shrivelled, or furrowed crust.
- 3.) Stream-tin ore from Alternon, committed in the fame manner to the porcelain-furnace, in a crucible of baked clay, yielded a compact light-yellow, and still somewhat clearer glass, that was found coated by a dull crust, of an isabella-yellow.

# SECOND SECTION.

# Experiments in the humid way.

THE extreme refistance which tin-stone opposes to acid menstrua has hitherto always prevented the complete success of its decomposition in the humid way; the reason of L14 which

must be sought for in the highly intimate and difficultly destructible combination of tin with oxygen. To be dissolved in acids, tin indeed, like other metals, requires a commensurate proportion of oxygen. But if that proportion be exceeded, as is the case with tin-stone, with putty or tinashes (the white, perfect oxyd of tin by ignition with access of air) with the oxyd of tin corroded by nitric acid, and similar other calces of that metal; the solution cannot take place, unless the excess of oxygen causing this impediment be previously removed.

#### A.

Till the present period, Bergmann\* was the only author, who has shewn a method of analysing tin-stone in the humid way: but unfortunately, I, as well as other chemists+, have sufficiently experienced its impersection. However, I entertained a hope, that the process recommended by him would most likely succeed when employed for wood-tin; on the ground, that of all tin-stones, this at least yields in some manner to the attack of acids; as I observed that 60 grains of it, reduced to an impalpable powder, and subjected to vigorous and long continued digestion with three ounces of nitro muriatic acid, had lost five grains of weight.

For this purpose, I digested 120 grains of finely pulverized wood-tin, for some time, with one ounce of concentrated sulphuric acid, and the affistance of a boiling heat. After this, I added by degrees two ounces of muriatic acid, and

<sup>\*</sup> Opuscula Physica et Chemica. vol. II. page 437.

<sup>+</sup> Chemische Annalen. 1786. 2 Band, page 126.

having digested it once more, I diluted the whole with water, and decanted the clear stuid from the undissolved residue which settled at the bottom. The same process was repeated twice with this last, adding each time half the above mentioned quantity of the acids. That portion, which continued insoluble, retained its original appearance, and weighed still 98 grains. The solution exhibited a yellow colour. When part of it was tried by Prussian alkali, the blue tinge manifested some latent portion of iron. The whole of the solution was, upon this, saturated with carbonated pot-ash; which produced a dirty white precipitate, weighing 27 grains in its dry state. Muriatic acid poured upon this precipitate rapidly dissolved it; and, on plunging into the solution, diluted with water, a thin stick of metallic zinc, there settled round it subtle lamellæ of reguline tin.

Yet, although, in this way the folution of wood-tin was in part accomplished, it would not succeed with other species of tin-stones, treated in the same manner. Such acids, as have been employed for this purpose, dissolved indeed the small portion of iron entering into the fossil, but exhibited feldom a slight trace of dissolved tin; and the powder of the tin-stone, subjected to the experiment, sustained only a very slight alteration in its appearance and weight.

Besides this, another circumstance connected with this method is yet to be remarked; which is, that each time, when muriatic acid is poured on the concentrated and heated sulphuric acid, clouds of muriatic vapours arise, detrimental to the health of the operator.

Therefore the problem, to decompose, in the humid way, tin-stones, and other calces of tin, fully saturated with oxygen, has by no means been solved by the process prescribed by Bergmann.

B.

Among those substances, which, by their near affinity with oxygen, afford a rational conjecture, that, by depriving tin-stone of part of its oxygen, they might prepare or render it fit for its solution in acids, sulphur principally seemed to deserve the trial.

Hundred grains of finely powdered tin-stone, from Schlackenwalde, mixed with an equal quantity of fulphur, were introduced into a fmall glass-retort. This being connected with a receiver, was lodged in a fand-bath, and gradually heated to an incipient ignition of its contents. When this process was accomplished, I found the sulphur sublimed, without any change in its natural state; while the residue, which preferved the former white-grey colour of the pulverized tin-stone, was hardly conglutinated, but had here and there some solitary, very minute, glittering, goldenyellow scales of aurum musivum spread on its surface. refidue was strongly digested with muriatic acid. although the muriatic fluid, separated from it by filtering, had, on combination with alkali, afforded fome oxyd of tin; yet its quantity was too inconfiderable, to make it reasonable to expect in this way a complete solution of tin-stone.

C.

After the above mentioned, and several other unsuccessful attempts, I proceeded to the application of caustic-potash. It was with satisfaction, that I found in this the means of accomplishing my purpose: so fully, that at present the complete analysis of tin-stone in the bumid way is no longer subject to any difficulty.

- 1. a) One hundred grains of tin-stone from Alternon, in Cornwall, previously ground to a subtle powder, were mixed in a silver-vessel with a lixivium containing 600 grains of caustic pot-ash. This mixture was evaporated to dryness in a sand heat, and then moderately ignited for half an hour. When the grey-white mass, thus obtained, had been softened while yet warm, with boiling water, it lest on the filter II grains of an undissolved residue.
- b) These II grains, again ignited with fix times their weight of caustic pot-ash, and dissolved in boiling water, left now only II grain of a fine yellowish-grey powder behind.
- c) The alkaline folution (a and b), which was in some degree colourless, was saturated with muriatic acid. A brilliant white, tender oxyd of tin was thrown down, giving to the mixture a milky appearance. This precipitate, re-dissolved by an additional quantity of muriatic acid, was precipitated afresh by means of carbonated soda. When lixiviated and dried in a gentle heat, it acquired the form of bright-yellowish, transparent lumps, having in their fracture a vitreous lustre.
- d) This precipitate, being finely powdered, foon and entirely diffolved in muriatic acid, affifted by a gentle heat. Into the colourless folution, previously diluted with from two to three parts of water, I put a stick of zink; and the oxyd of tin, thus reduced, gathered around it in delicate, dendritic laminæ of a metallic lustre. These, when collected, washed, dried, and sused, under a cover of tallow, in a capsule placed upon charcoal, yielded a button of pure metallic tin, weighing 77 grains.

# 524 LXI. Chemical Examination of Tin-Ores.

e) The above mentioned refidue of  $1\frac{1}{4}$  grain, left by the treatment with caustic pot-ash (b), afforded with muriatic acid a yellowish solution; from which, by means of a little piece of zink introduced into it,  $\frac{1}{2}$  grain of tin was still deposited. Prussian alkali, added to the remainder of the solution, produced a small portion of a light-blue precipitate; of which, after subtracting the oxyd of tin now combined with it, hardly  $\frac{1}{4}$  of a grain remained, to be put to the account of the iron contained in the tin-stone, here examined.

In these experiments, (excepting only a slight indication of filex amounting to about \(\frac{3}{4}\) of a grain), no trace has appeared, either of tungstenic oxyd, which some Mineralogists have supposed to be one of the constituent parts of tin-stone, nor of any other fixed substance. Therefore, what is desicient in the sum, to make up the original weight of the sofil analysed, must be ascribed to the loss of oxygen; and t us the constituent parts of pure tin-stone from Alternon are to each other in the sollowing proportion:

Tin .				77,50
Iron .				0,25
Silex		,		0,75
Oxygen	2			21,50
				100

- 2.) I repeated the same experiment with washed needletin from Polgooth, and obtained nearly the same result.
- 3.) Hundred grains of brown tin-stone from Schlacken-walde, decomposed in the same manner, by means of caustic alkaline lye and muriatic acid, yielded 75 grains of reguline tin; but its portion of iron amounted to ½ grain.

#### LXII.

## CHEMICAL EXAMINATION

OF THE

# NATIVE SULPHURET OF TIN\*.

(Tin-pyrites. Zinnkies.)

THE Tin-pyrites, or fulphuret of tin, which at Wheal Rock, in the parish of St. Agnes, in Cornwall, at the depth of 20 fathoms under ground, forms a vein of 9 feet in thickness, is the first, and as yet the only instance of a natural tinore mineralized by sulphur. Bergmann+, it is true, mentions such an ore as coming from Siberia; but it has never yet been found there; and what this celebrated chemist has considered as such, and examined, was not a true fossil, but a suppositious product of art 1.

The colour of this tin-pyrites is grey, of various degradations from the light to the dark, and in the purer specimens approaching to the silvery white. It is found in small lumps, possesses a moderate metallic lustre, and exhibits an uneven, small-grained fracture. Its texture appears to be foliated, and its fragments are, for the most part, indeterminately an-

<sup>\*</sup> Beob. u. Entdeck. a. d. Naturkunde. vol. I. pages 155 and 169.

<sup>+</sup> Opusc. Phys. et Chem. vol. III. page 158.

I Grell's Chem. Annalen. 1790. vol. I. page 53.

gular. It is also very brittle, and easily triturated\*. Its specific gravity, as I found, is 4,350.

According to the following analysis, the constituent parts of this ore are *Tin*, *Copper*, *Iron*, and *Sulphur*. For this reason, the name of *Bell-metal ore* has been given it, not very improperly.

Tin pyrites contains, befides the copper chemically mixed with it a sone of its conflituent parts, likewise copper-pyrites; which in part is coarsely, and in part finely disseminated in it. From this accidental ingredient, I previously freed, as much as possible, the tin-pyrites, or native sulphuret of tin, subjected to the following examination.

#### A

Half an ounce of tin-pyrites was heated to redness in a small glass-retort. In the receiver a moisture was found, making about two drops, impregnated with sulphureous acid. The neck of the retort became thinly lined with a little grey and yellow sublimate, of about 4 grain of weight; which, when placed on a glowing coal, first smelled and burned like sulphur; but after this, a faint odour of arsenic was perceptible. The tin-pyrites lost three grains of weight.

B.

Two drachms of tin-pyrites were roasted in a calciningpot, till no longer any sulphureous smell could be observed.

<sup>\*</sup> A more detailed description of the external properties of tinpyrites, by Karsten, may be seen in Beob. u. Entd. a. d. Naturkunde. vol. IV. page 391.

By

By this the ore was converted into a red calx or oxyd, weighing two drachms and 20 grains. It was then mingled with equal parts of calcined borax, half a part of white glass, and one fourth part of colophony. Being introduced in this state into an assay-crucible (Tute), lined with powdered charcoal, and covered with common salt, it was kept in a state of strong sustion for half an hour: by which treatment it yielded a metallic button of a grey colour, 10 grains in weight, but very brittle; so much so, that by a gentle stroke with the hammer it slew in pieces. The remainder of the reduced metal lay dispersed in small grains among the pulverulent scoriæ, mingled with the charcoal-dust, that was employed to line the vessel.

## C

- a) Two drachms of finely triturated tin-pyrites were treated with an aqua regia, composed of one ounce of muriatic and ½ ounce of nitric acid. Within 24 hours the greatest part of the metallic portion was dissolved in it, without application of heat; while the sulphur rose up, and sloated on the surface of the menstruum. After the mixture had been digested upon it for some time in a low sand-heat, I diluted it with water, and siltered it. It lest 43 grains of sulphur on the paper, still, however, mixed with metallic particles. When the sulphur had been gently burnt off on a test, there still remained 13 grains; of which eight were dissolved by nitro-muriatic acid. The remaining part was then ignited with a little wax; upon which the magnet attracted one grain of it.—What remained was part of the siliceous matrix, and weighed three grains.
- b) The folution of the metallic portion (a) was combined with carbonat of pot-ash; and the dirty-green precipitate,

pitate, thus obtained, was re-dissolved in muriatic acid, diluted with three parts of water. Into this sluid a cylinder of pure metallic tin, weighing 217 grains, was immersed. The result was, that the portion of copper contained in the solution, deposited itself on the cylinder of tin; at the same time that the sluid began to lose its green colour, from the bottom upwards; until, after the complete precipitation of the copper in the reguline state, it became quite colourless.

- c) The copper thus obtained weighed 44 grains. By brisk digestion in nitric acid, it dissolved, forming a blue tincture, and left one grain of tin behind, in the character of a white oxyd. Thus the portion of pure copper confisted of 43 grains.
- d) The cylinder of tin, employed to precipitate the copper, now weighed 128 grains; fo that 89 grains of it had entered into the muriatic folution. From this, by means of a cylinder of zinc, I re-produced the whole of its dissolved tin, which was loofely deposited on the zinc in a tender dendritical form. Upon being affured, that all the tin had been precipitated, I collected it carefully, lixiviated it cleanly, and fuffered it to dry. It weighed 130 grains. I made it to melt into grains, having it previously mixed with tallow, and under a cover of charcoal dust, in a small crucible; which done, I feparated the powder of the coal by elutriation. Among the washed grains of tin, I observed some black particles of iron, which were attracted by the magnet, and weighed one grain. Deducting this, there remain 129 grains for the weight of the tin. By subtracting again from these last those 89 grains, which proceeded from the cylinder of tin employed for the precipitation of the copper (b), there remained 40 grains for the portion of tin contained in the tin-pyrites examined. Hence, including that one grain of

tin, which had been separated from the solution of the copper (c), the portion of pure tin contained in this ore amounts to 41 grains.

The educts, or substances, extracted in this process from tin pyrites, were consequently:

Sulphur			. 1	2	30	grains.
Tin .					4.1	
Copper					43	
Iron.					2	
Vein-ston	e, or	gan	igue	1	3	i ann
				I	19	

Which makes in an hundred parts:

Sulph	ur				25	
Tin				•	34	
Copper	148				36	
Iron		1114			2	
. A .	PAI S			WELL ST	97	-

However, this proportion of the constituent parts is not always constant. The darker varieties of tin-pyrites, in particular, are considerably poorer in tin; as, from one of them I scarcely obtained one half of the above quantity of reguline tin: but their proportion of iron increases.

#### D.

Although, in the course of these experiments, no trace of any silver, or lead, which had been suspected to exist as an ingredient in this sossil, had appeared; yet, for the sake of greater certainty, I instituted the sollowing trial. The tin-pyrites, that had been ignited in the retort (A) was treated with nitric acid; which attacked it, emitting copious

pious red vapours. After sufficient digestion, I diluted the mixture with water, and separated the remaining sulphur and oxyd of tin by means of the filter; combining, afterwards, the clear, blue solution, both with muriatic and sulphuric acids. But, by its continuing clear and unchanged, it shewed that neither silver nor lead are present in this ore.

#### E.

The ready folubility of tin, contained in this ore, in the nitro-muriatic, as well as in the muriatic acid, which does not take place in tin-stones, and all other oxyds of tin fully saturated with oxygen, is a sufficient proof that, in this ore, the tin held in solution by the sulphur, in a manner, approaches the state of native, or reguline tin. This is farther corroborated by the following experiment.

- r. a) I exposed half an ounce of tin-pyrites, mixed with the same quantity of corrosive sublimate, to a sand-heat, in a small retort, connected with a receiver. At the very first moderate action of the fire, a heavy sluid passed over, attended with heavy white vapours; and, on the increase of heat, a grey-yellow sublimate, for the most part crystallized in needles, settled on the neck of the retort; at the same time that on its upper convexity an impure black-grey cinnabar, or sulphuret of mercury, deposited.
- b) The strongly-fuming sluid in the receiver, which gave out thick white sumes, weighed one drachm, and perfectly resembled common fuming liquor of Libavius, or sublimed solution of muriat of tin. From this, by dilution with water, and saturation with pot-ash, the oxyded tin was thrown down, as a white, very tumid precipitate, which, edulcorated and dried, weighed 30 grains.

- c) The sublimate, separated from the neck of the retort, was pulverized, digested with water, and filtered. The residue which it lest on the paper amounted to 203 grains, when desiccated. These were dissolved in nitro-muriatic acid, with the exception of 15 grains of sulphur; and the mercury fell down, in the reguline state, from the solution, by putting copper into it. The aqueous solution of the sublimate, obtained by the digestion, and precipitated by carbonat of pot-ash, afforded 16 grains of oxyded tin; which were added to the preceding (b).
- d) The oxyd of tin was then diffolved in muriatic acid, and again precipitated, in the metallic state, by a piece of zinc, plunged into the solution. This reguline tin, when collected, washed, and melted with tallow, weighed 20 grains. I stattened it by beating with the hammer; cut it into pieces; digested it with nitric acid; and dropped Prussian alkali into the sluid, filtered off from the oxyd of tin. The sew brown slocculi precipitated by that alkali, proved that the muriated tin had carried along with it a slight portion of copper.
- 2.) By way of a comparative experiment, I repeated this process with a species of pure tin-stone; but, in this case, not the least trace appeared of any solution of the tin. The mercurial sublimate volatilized in its usual needled form, and the tin-stone remained in the retort unaltered.

#### LXIII.

## CHEMICAL EXAMINATION

OF THE

## MOLYBDAT OF LEAD,

(Yellow Lead-ore),

From BLEIBERG.

# FIRST SECTION\*.

t.) THE yellow lead-ore, or Molybdat of Lead, from Bleiberg, near Villach, in Carinthia, conflitutes, in the genus of lead, a particular, very diffinguished species of ore, occurring in many beautiful varieties. Its colour is waxy-yellow, of various shades; some inclining to the reddish, others to the whitish-grey. For the most part it is crystallized in tables, of from four to eight sides, which sometimes stand singly on their edges, or narrow sides, and, at times, are cellularly concreted. Those specimens of it are rather scarce in which the crystals form a cube, or an octahedron, instead of a table.

The matrix, in which this ore is imbedded, is a compact lime-stone, of a yellow, whitish, or grey colour.

2.) Most mineralogists seem to have become acquainted with this lead-ore, only since the time that facquin + published his treatise on it; after whom Wulfen; has contri-

<sup>\*</sup> Beob. u. Entdeck. a. d. Naturkunde. vol IV. 1792, page 95; and vol. V. 1794, page 105.

<sup>†</sup> Miscellanea Austriaca. vol. II. Vienna, 1787.

<sup>‡</sup> Xav. Wulfen. Abhandlung vom Kärntbner Bleispathe. Wien, 1785.

buted to the knowledge of this ore, by the elegant and accurate description which he has given of it. As to the conflituent parts of the yellow lead-ore, the following experiments will shew that the substance with which the lead is combined in this mineral is not the oxyd of tungften, as has been erroneously supposed, but the oxyd of molybdena.

full a west metallic taile

- 3.) The first point which I had in view, was to separate this lead-ore carefully from the adhering extraneous parts. Finding that diluted nitric acid shewed in the cold no action on this fossil, I affused upon the quantity of it deftined for this analysis small portions of this acid; pouring it off again as foon as the effervescence ceased. This process I repeated, till, at last, no more effervescence ensued on adding a fresh portion of the acid. Upon this the ore was washed with water, and desiccated. The nitric acid employed for this purification contained the calcareous earth proceeding from the matrix, which outwardly adhered to the ore, and formed gypfum with fulphuric acid, by means of which I precipitated it. At the fame time, a confiderable portion of a fine, red iron-ochre was washed off by this process, which diffolved by digestion in muriatic acid, leaving a flight refidue, confifting of lead-ore and filiceous earth.
- 4.) Two drachms of the above-mentioned crystals of leadore, thus purified, were mixed with an equal quantity of carbonated pot-ash, and exposed to the fire in a small crucible. It entered into fusion without effervescence. The refrigerated mass exhibited a faint reddish tinge, and was covered on its upper part with fcales, refembling litharge. Having foftened this alkaline mass with water, and filtered, I faturated the colourless solution with nitric acid. By this the mixture was not rendered very turbid; but, on the next day, I found the bottom of the glass covered with cryf-

M m 3

tals of 1 of an inch long, flanding upright; which I examined as follows:

- a) Their figure confifts of small, brilliant, accumulated rhomboidal tables.
- b) On the tongue they manifest a weak metallic taste.
- c) Under the blow-pipe, upon charcoal, they fuse very quickly and calmly into little globules, or drops, which are inflantly imbibed by the ignited coal.
- d) In the filver spoon they melt into grey spherules, which become shrivelled as they cool; and, during the current of air, urged through the blow-pipe, they deposit a white substance, which covers the spoon.
- e) When put upon a globule of alkaline phosphat, fused on the charcoal, they are rapidly dissolved, and tinge it either of a grass, or olive-green, according to the quantity in which they are added.
- f) They entirely dissolve in water, by the assistance of heat.
- g) Prussian alkali produces from this solution a copious, flocculent precipitate, of a light-brown colour.
- b) If, into the aqueous folution (f) a little muriatic acid be dropped, and a fmall piece of tin be put into it; or, if some of those crystals are immersed in a muriatic folution of tin; in both these cases the fluid acquires a deet-blue colour.

In confequence of these appearances, I think I do not err in confidering these crystals as molybdic acid, neutralized pot-ash; because, in a comparative experiment, the same relations were shewn by molybdic acid, that had been prepared from molybdena of Altenberg, by detonation with nitre, and subsequent precipitation, effected by nitric acid, from the filtered solution of the mass produced by the detonation, and which acid likewise assumed a crystalline form in drying.

5.) As it was obvious, from the state of the calciform lead, which remained on the paper when I filtered the folution of the fused mass (4), that the whole of the yellow leadore employed had not been decomposed, I repeated the experiment, increasing, however, the proportion of the alkali; fo that, for two drachms of the ore, I took 10 drachms of carbonated pot-ash. I also kept the mass for a somewhat longer time in fusion; after which it was poured out, levigated, foftened with water, and thrown upon the filter. This alkaline folution I faturated with muriatic acid, at first only incompletely; whereby, at a warm temperature, a white precipitate was produced, in the form of a cheefy coagulum. This precipitate contained, indeed, molybdic oxyd, but mixed with a greater portion of oxyded lead; which last, upon folution in muriatic acid, separated in needle-shaped crystals of muriat of lead.

When this precipitate had been separated from the alkaline solution, which before was saturated with only half the quantity of muriatic acid required, I combined that sluid with an additional portion of the same acid to its complete saturation. It became again turbid, but only moderately so. Upon this, a white precipitate accumulated, like starch, subsiding in cold water; which, carefully edulcorated and dried, was examined in the same manner as the crystalline precipitate mentioned before, (4). Its habitudes were perfectly the same; except that it would not dissolve

alone in water, but formed a clear folution, only when a few drops of muriatic acid had been added.

The fluid was now concentrated by evaporation; after which the oxyd of molybdena, still contained in it, fell down as a fine, heavy, yellow powder; which, after proper lixiviation and drying, exhibited a beautiful, faturated lemon-colour.

- 6.) The white oxyd of lead, which remained upon the paper on filtering the foftened mass, produced by the fusion of the ore with pet-ash (4), was found contaminated with a portion of filiceous earth. When treated upon charcoal, it did not entirely melt into a metallic button; but part of it was converted into a clear, bright, yellow globule of glass of lead (vitreous oxyd): for the admixed filiceous earth prevented the reduction of the whole portion of lead; in the same manner, as is the case when it is attempted to reduce upon charcoal a glass of lead, that has been made of three parts of oxyded lead and one of filex. For this reason, I disloved the above-mentioned oxyd of lead in dilute nitric acid, separated the filiceous earth by filtration, and precipitated the metal from the solution, by means of sulphuric acid, in the character of sulphated lead.
- 7.) I likewise examined the actions of some of the acids upon this Carinthian lead-ore.—One drachm of it was digested with a copious quantity of nitric acid; which diffolved the greatest part, but not the whole of it. In the solution were observed white, loose slocculi dispersed, which dried upon the siltering paper in the form of a membrane, and became tarnished of a blue by exposure to daylight. This substance had much resemblance to the molybdic oxyd, obtained from molybdena in the humid way, by repeatedly distilling nitric acid from it. The filtered nitric

folution contained, besides the portion of lead, a considerable quantity of molybdic oxyd. Sulphuric acid precipitated the lead from it; and Prussian alkali afterwards threw down the molybdena in loose, brown, red particles.

- 8.) One drachm of this yellow-lead ore, previously purified, afforded a clear folution, by digestion with murlatic acid. The folution went on gradually, and was nearly complete and colourless; but it soon deposited white crystals of muriated lead. Only a slight portion of silex was left behind, which I separated. While I was concentrating the sluid, the saline crust settling on the sides of the evaporating dish became tarnished of a fine blue; which as often disappeared as the crust was re-dissolved in the sluid, on gentle agitation. When the concentrated sluid had been decanted from the muriat of lead, which still subsided, it assumed a beautiful deep-blue, but lost that colour again by dilution with water. When afterwards saturated with potash, it dropped a white oxyd of molybdena.
- 9.) Oxyd of lead, and oxyd of molybdena, therefore, are the conflituent parts of the yellow lead-ore from Bleiberg, in Carinthia. This combination is remarkable, as it is the first instance of the kind; since molybdena has not yet occurred any where, except in its proper ore (Wasserbley). From the foregoing experiments there also result some other observations, by which the knowledge of the chemical properties of that metallic substance (molybdena) is greatly enlarged. To these belongs its external form, as it occurs partly in the crystalline state, partly as a white, and partly as a lemon yellow oxyd. In the first state, it is soluble in simple water, as well as in acids; in the second, a small addition of muriatic acid promotes its solution in water; but in the third, or that of a yellow oxyd, it resuses to dissolve both in water and in acids. The cause of this

difference confifts in this, that in the two first cases it has been neutralized with the portion of alkali that remained combined with it; whereas, in the last case, that is, in the form of a yellow earth, it is more in the state of a mere metallic oxyd.

10.) This appearance of the molybdic oxyd with a yellow colour, has probably been the reason for considering the substance, by which this yellow lead-ore is mineralized, as tungstic acid.

However, the blow-pipe alone is sufficient to distinguish these two metallic substances from each other; for, the yellow molybdic oxyd loses its colour at the first contact with the point of the slame, and is rendered olive-green; it also immediately runs into a small globule, or drop, which is very soon absorbed by the charcoal; and, lastly, when suffed with a neutral phosphat, it tinges the button which thence arises of a green colour.

The yellow oxyd of tungsten, on the contrary, exchanges, by ignition, its yellow colour for a blue or black, at the same time that it remains upon the charcoal as perfectly infusible; and when fluxed with phosphoric salt, it gives a sky-blue colour to the saline globule.

# SECOND SECTION.

HAVING thus obtained, by means of the experiments here explained, the knowledge of the constituent parts of the yellow lead-ore from Carinthia, I had yet to discover their proportions to each other. This I accomplished in the following way.

a) A hundred grains of the crystals above described were carefully freed, in the manner before mentioned, from the

adhering calcareous earth and ochre of iron, and then finely pulverized. They were then diffolved in muriatic acid, affished by heat, alternately affusing upon them the acid, and a large quantity of water. In this instance a trace of filiceous earth, though scarcely discernible, appeared.

- b) The greatest part of muriat of lead, generated in the process, was deposited in fine needles, even before the solution had completely grown cold. The super-natant clear study was then poured off, reduced to a smaller volume by evaporation, and freed from the muriated lead, which still separated. The muriated metal, collected with care, and briskly desiccated, weighed 74½ grains. By dissolving it in hot water, and steeping into the solution a polished piece of iron, the lead precipitated upon this last in fine lamellæ, and in the metallic state.
- c) But in order to find more accurately what proportion this muriated lead might bear to pure oxyd of lead, I made the following experiment.

Two hundred grains of lead, cut into shreds, were diffolved in 300 grains of nitric acid, diluted with 10 ounces of water, and, with the affistance of digestion, in a boiling heat. The solution was then divided into two parts.

- 2) Into one half I dropped muriatic acid, as long as it produced any turbidness; evaporating afterwards the mixture to the most perfect dryness of the residue. The muriat of lead here produced weighed 133 grains.
- B) From the fecond half of the nitric folution I precipitated the oxyd of lead by diffolved caustic potash. This oxyd, when edulcorated and briskly dried till it began to turn yellowish, amounted to 115 grains.

From

# 540 LXIII. Examination of the yellow Lead-ore, &c.

From this it followed that those  $74\frac{1}{2}$  grains of muriated lead, obtained from 100 grains of the yellow molybdat of lead (b), are equal to 64,42 grains of pure exyd of lead.

d) The concentrated muriatic folution of molybdena, which had a blue colour, was mixed with nitric acid, and lodged in a fand-bath for farther evaporation. Being thus circumstanced, it was again divested of its blue colour, and a yellow oxyd of molybdena separated. But when the evaporation had been carried on to complete dryness, I collected and weighed the remaining lemon-yellow oxyd of molybdena; and found it amount to 34½ grains.

Wherefore, one hundred parts of the purest crystals of the yellow lead-ore, from Carinthia, contain:

Oxyd of lead			64,42
Oxyd of molybdena	PATE!		34,25
in mixelianed en in	300	-	MEDI 807
			98,67

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#### LXIV.

## CHEMICAL EXAMINATION

OF THE

# SULPHURET OF COPPER,

(Vitreous Copper-ore. Kupferglanzerz)

From SIBERIA.

AMONG the copper-ores, the first place belongs to the grey, or vitreous Copper-ore, it being the richest in copper, and containing, besides its mineralizer, which is sulphur, the fewest foreign admixtures. Its purer varieties possess a degree of softness, so that they admit of being in some manner cut with the knife; and on the recent cut they resemble metallic lead in colour and lustre.

This ore usually occurs in compact masses; it is seldom crystallized. Of this latter fort I possess some from Poldice and Dolcoath, in Cornwall, in druses (groups of regular crystals) of minute white-grey, resplendent, tetrahedral, truncated pyramids.

For the subject of my enquiry, I took the massive, compact, moderately-soft vitreous copper-ore, from the mine Gumeschefskoi, on the river Turja, in the district of Catharineburg; where it is found in considerable large masses, which, in the partings, are invested with azure copper-ore, and sibrous malachites. It was freed from these previously to its being subjected to the following experiments.

#### A

a) Upon two hundred grains of the ore, coarfely powdered, moderately strong nitric acid was affused, which attacked and dissolved them with frothing and extrication of red vapours. The solution was clear, and the sulphur alone in the ore was left behind, floating in the fluid, in grey, loose, flocculi, without any other residue; which indicated that no antimony was present. The sulphur collected on the filter was heated in a small crucible to inflammation, and it burned with its peculiar odour, without any trace of arsenic; yet leaving a slight portion of oxyded iron and filiceous earth.

b) The folution, which had a pure blue colour, was treated first with muriat, and then with sulphat of soda. But none of these, nor any other salt, rendered it turbid, or produced any other alteration; by which it appears, that this ore contains neither silver nor lead.

#### B.

a) To determine, with proper accuracy, the proportion of the conflituent parts, I repeated the examination in the following manner. Two hundred grains of the powdered ore were combined and heated with muriatic acid, to the degree of boiling. But as this acid alone manifested no action on it, I added nitric acid gradually, by drops; which exerted a strong attack in each instance. When the solution of the ore had been accomplished, I separated the sluid from the sulphur floating on the surface; and digested this last once more with a fresh quantity of muriatic acid, dropping into it some nitric acid; after which I collected it upon the filter. This sulphur, washed and desiccated, weighed 38½ grains, out of which, after its combustion, 1½ grain

grain of filiceous earth remained; fo that the true amount of fulphur was 37 grains.

- b) The folution exhibited a glass-green colour. I divided it into two parts. Into one half polished iron was immersed; upon which the copper precipitated of a dendritical form, and pure metallic brilliance. It weighed  $78\frac{7}{2}$  grains, when washed, and immediately desiccated in a moderate temperature.
- c) In order to ascertain the proportion of iron contained in the ore, I combined the other half of the solution with caustic ammoniac added to excess of saturation. The precipitated iron remained behind, in the form of a subtle brown mud, which, collected on the filter, desiccated and ignited, weighed three grains. But as the iron is contained in the mixture of the ore, not in this calciform state, but in the reguline, which last is to the first in the proportion of 3 to 4, these 3 grains of oxyded iron give 2½ of metallic iron to be added in the computation.

Therefore, hundred parts of the Siberian vitreous copperore confift of:

Copper			B	3)		78,50
Iron .				c)		2,25
Sulphur						
Silex						
						100 -

C.

Copper-ores eminently belong to those kinds, the component principles of which are but imperfectly determined by analysis in the dry way. The reason of this is, partly, that the alkaline falts employed for the reduction, exert, during fusion, as well as in the humid way, a very strong folvent power on copper.

But although the reducing flux, composed of glass, borax, and charcoal-dust, recommended by Gellert, Tillet, and others, instead of alkalis, is reckoned one of the best; yet I have always found the common black-flux, if employed in the following manner, the most effectual.

Two docimastic centners (each of 100 parts, considered for as many pounds), of the triturated ore were mixed with half a centner (or 50 parts), of charcoal-dust, and properly roasted until all the coal was consumed\*. I then blended it with  $\frac{x}{2}$  centner of colophony and 6 centners of the black flux, covering the mass in the assay-crucible with common salt, and exposing it to a forge heat. After the coals were completely red, the blowing of the bellows was kept up for 20 minutes. The suspense for a second single fluxed score, 138 parts of a sine red, or refined copper; which is 69 per cent.

However regularly this affay in the dry way was performed, yet it produced  $9\frac{1}{2}$  per cent. less than the true proportion of the copper in the ore amounts to. The humid way, therefore, is, in every respect, the most certain to discover the true quantity of copper in any ore.

<sup>\*</sup> The roasted-ore weighed 210 pounds.

#### LXV.

## CHEMICAL EXAMINATION

OF THE

## VARIEGATED COPPER-ORE.

(Bunt-kupfererz. Purple Copper-Ore, by Kirwan.)

THE variegated Copper-ore is distinguished in its external appearance from the vitreous, to which it is the nearest a-kin, by it svariegated colours, resembling those of tarnished steel; and, with regard to its constituent parts, it differs from it in containing less copper, but, on the contrary, more iron.

## FIRST SECTION.

Variegated Copper-Ore from Hitterdahl.

THE variegated copper-ore occurring at Hitterdahl, in Norway, in lumpy masses, exhibits, on its recent fracture, a mixture of colours of light-blue, tin-white, and copper-red; which, however, by exposure to air, gradually change into a more uniform steel-blue.

#### A.

One hundred grains of the pulverized ore were subjected to gentle digestion with nitric acid, whose action upon it was but moderate. From the residue, the sulphur was driven out by combustion. This residue, when a second time digested with nitric acid, dissolved in it, leaving only a slight portion of a red oxyd of iron. On examining the

folution, first by common falt, and then by Glauber-salt, it continued limpid and unchanged.

# CURMICAL E. AMINATION

- a) Upon two hundred grains of the powdered ore muriatic acid was affused, the mixture heated, and then combined in small portions with nitric acid. The solution, which was thus performed, had a brown colour while concentrated; but as soon as it was diluted with water, it acquired a green. The remaining sulphur was grey, tenacious, and spongy, and weighed 72 grains when dry. By slow combustion it left 35 grains, of which, after extraction by muriatic acid, sive grains still remained behind. These lost one grain more of sulphur by burning, and the remaining four grains dissolved entirely in muriatic acid. Whence the quantity of sulphur amounted to 38 grains.
- b) The muriatic folution was divided into two equal parts; and the copper was precipitated from one of them by means of iron. It amounted to  $69\frac{1}{2}$  grains.
- c) The other half was super-saturated with caustic ammoniac, and the oxyd of iron which fell down was collected. This, when moistened with linseed-oil, and exposed to a low red-heat, weighed 10 grains; which are equal to  $7\frac{1}{2}$  grains of metallic, or reguline iron.

Thus, in one hundred parts or this variegated copper-ore from Norway were found:

Copper .		B. b) .	Sie !!	69,50
Sulphur	1000	. a) :	will.	19
Iron .		· c) .		
Oxygen			vi cir	4
On emin			pos re	100

In supplying the deficiency in the sum of weights of the copper, iron, and sulphur, from the hundred, by putting oxygen in the account, I mean to characterize this last as a constant constituent part of the variegated copper-ore, producing in it those variegated colours: in the same manner, as in steel, in copper-pyrites, and other metallic substances, the beginning of their oxydation is indicated by a similar diversity of colours.

In the last mentioned substances, however, the change-able colours are only owing to external causes; for which reason, they present themselves only on the surface, when long exposed to air. On the contrary, the variegated copper-ore is penetrated throughout its whole mass by the oxydating principle. This corresponds with the deficiency of weight to make up the sum of the fixed constituent parts of the ore here analysed; whereas no such loss is observable in the vitreous copper-ore, treated and decomposed by the same method. It is on this account also, that the action of the nitric acid is less strong, and the disengagement of nitrous gas is less copious, in the variegated than in the vitreous copper-ore.

# SECOND SECTION.

# Variegated Copper-Ore from Rudelftadt.

THE native place of this variety of variegated copper-ore is the mine Friederike Juliane, at Rudelftadt, in Silefia, in which a rich vein has lately been opened, of beautiful native filver, imbedded in ponderous spar, and accompanied by pyramidal red silver-ore, along with crystallized white co-balt-ore (Glanzkobalt), that has raised the ardent wishes of the proprietors for its continuance.

#### A

Two bundred grains of the powdered ore, having been twice extracted by means of nitric acid, left behind their fulphureous ingredient, together with a quantity of red oxyd of iron. The folution was filtered, and tried by proper reagents for filver, lead, zinc, arfenic, and the like, and it afforded no indication of these, but only of copper and iron.

#### B.

- a) Two hundred grains of this ore, in pure pieces, freed from interspersed quarz, were triturated, and treated with muriatic acid, to which a little nitric acid was afterwards added, and the extraction continued in a moderate warmth. The colour of the filtered solution was a celadon, or blueish green, with a shade of grey. The residue, porous like sponge, weighed at first 88 grains; but only 56 grains, after its sulphur had been gently burned off. These, digested in a low heat with muriatic acid, soon dissolved, forming a brown fluid, and left fix grains more of sulphur behind. Hence, the sulphur contained in those 200 grains amounted to 38 grains.
- b) These solutions were mixed together, and divided into two equal parts. From one half I precipitated the copper in due manner by means of a polished piece of iron, and obtained 58 grains.
- c) The other half was treated with caustic ammoniac, until the oxyd of copper, precipitated in the beginning, again dissolved. The oxyd of iron, thus obtained, when collected on the filter, washed and desiccated, was moistened with linseed-oil, and ignited in a covered crucible. It

weighed 24 grains. Hence, as, upon an average, four parts of oxyded iron, attractible by the magnet, are to be estimated as equal to three parts of reguline iron, I reckon 18 grains of metallic iron, instead of these 24 grains.

Since, for the fame reason as in the foregoing analysis, the loss of weight in the sum of the fixed constituent parts must be taken for the oxygen combined with the ore, and which escaped in the process; the constituent parts of the Silefian variegated copper-ore, and their proportions in the hundred, will be:

property and		C			-74	-	100
Oxygen							5
Sulphur			a)				19
Iron .			c)	01.1			18
Copper		В.	b)		,		58

With a view of making an affay in the dry way, I roafted two docimaftic centners with half a centner of powdered charcoal. The roafted ore, now weighing 206 lb. was then mixed with half a centner of colophony, and fix centners of black flux. In this flate it was put in a crucible, and covered with muriat of foda. When kept in fusion during 20 minutes before the nozzle of the bellows, it yielded a fine button, weighing 96 lbs. of red, or refined copper; which is 48 per cent. and hence, 10 lbs. short of what was obtained in the humid way, (B. b).

#### LXVI.

# CHEMICAL EXAMINATION

OF THE

# SIBERIAN MALACHITES.

- a) ONE thousand grains of compact, reniform Malachites, from the Turjin mines, on the Ural, were reduced to powder, and heated to complete redness in a small glass retort, connected with the pneumatic apparatus. Much carbonic acid gas was disengaged in this process, to the amount of 252 cubic inches, without reckoning that part which was absorbed by the water of the apparatus. This gas was entirely absorbed by lime water, at the same time that a proportionate quantity of carbonated or crude calcareous earth was produced. In the intermediate small receiver a moisture collected, weighing 78 grains, which, upon trial, proved to be pure water.
- b) The pulverulent residue taken out of the retort appeared of a black colour, and weighed 716 grains. To serve for the following experiments, it was divided into sour parts, at 179 grains each; and hence corresponding to 250 grains of the rough malachites.
- chites, combined with three times its quantity of black flux, were put into an affay-crucible, without lining it, and covered with muriated foda. In this fituation it was committed to the fire of the blaft-furnace, and when the coals had become red-hot without the action of the bellows, it was kept melting

for the space of twenty minutes. After cooling, it was observed that, in the broken retort, the whole mixture, under the covering of common salt, had run into an uniform, compact, and opake mass, of the bright red-colour of ordinary sealing-wax, and that no metallic button had been formed.

It follows from this, that there was not carbon enough present to take up entirely the oxygen of the metallic oxyd. Therefore the copper has, by means of this small remainder of oxygen still united with it, been brought into the state of red oxyd of copper; and, as such, it has disfused itself uniformly through the alkaline salt.

- 2.) Hundred and feventy-nine grains of ignited malachites were mingled with three times their quantity of black-flux, and 1-10th of powdered charcoal. When fused in this state, during 20 minutes, under a stratum of common salt, in an assay-crucible not lined in the inside, they afforded a button of reguline copper, which had run well together, and weighed 136½ grains.
- 3.) Another 179 grains of ignited malachites, mixed with thrice as many grains of black-flux, and one fifth part of their weight of colophony, and likewised fused for 20 minutes, under a cover of muriat of soda, in a crucible not secured by lining, yielded a well-melted button of reguline copper, weighing 138 grains.
- 4.) The remaining 179 grains of ignited malachites were, like the preceding, melted during the time of 20 minutes, under a cover of common falt. But the affay-crucible had previously been lined with powdered charcoal, and the malachites mingled with an equal weight of calcined borax, with half-its quantity of white glass, and 1-4th part of colo-

phony

phony, or boiled turpentine. By this process I obtained, indeed, a well-fused button of reguline copper; but with a considerable loss, as it weighed only 105½ grains.

#### B.

In order to discover more accurately the constituent parts of malachites, I performed the following experiments.

- a) 100 grains of malachites, reduced to powder by trituration, were diffolved in nitric acid; which was effected without leaving any refidue. The folution had a bright-blue-colour, and was faturated to excess with caustic ammoniac: but the precipitate produced was entirely, and without turbidness, re-diffolved by the excess of the alkali. This shewed that the malachites here examined was perfectly free from iron, and similar admixtures.
- b) I combined hundred grains of triturated malachites with a fufficient quantity of fulphuric acid, previously diluted with five parts of water, and accurately weighed together with the vessel. After the malachites had been wholly dissolved, which was effected gradually, and with a moderately strong effervescence, the loss of weight, occasioned by the carbonic acid gas that was extricated, was found to consist of 18 grains.
- c) One bundred grains of the same powdered malachites were ignited, at a moderate heat, in a covered crucible. The black residue had lost 29½ grains in weight. If from these be subtracted 18 grains for the carbonic acid, the remaining 11½ grains of loss will consist of water.

Another

d) And lastly, 100 grains, which had been dissolved in dilute sulphuric acid, and precipitated by zinc, yielded 58 grains of pure copper.

In consequence of these experiments, the Siberian malachites consists, in the hundred, of:

Copper					6		58
Carbonic	a	id			*		18
Oxygen				0.			12,50
Water			0		.0		11,50
						-	

100

in bowlo

big same ville LXVIII.

## CHEMICAL EXAMINATION

OF THE

# BISMUTHIC SILVER-ORE,

From Schapbach, in the Black forest,

In Suabia.

THE Bismuthic Silver-ore, which occurs in the mine Friederich-Christians, in the valley Schapbach, in the Black-forest, (Schwarzwald), and for the first acquaintance with which we are indebted to Mr. Selb\*, Master of the mines at Wolfach, has been described, as to its external characters, by Widenmann † and Emmerling‡. This mineral deserved a complete chemical inquiry so much the more, as even now several Mineralogists still seem to doubt of the existence of this peculiar species of ores.—For this reason, I publish here its analysis, which to perform I was enabled by Mr. Selb, sending me of this mineral the quantity necessary for the purpose.

Since this ore is very much concreted with the grey quarz, ferving to it as a matrix; and fince in most specimens it can be considered as only disseminated in the quarz, I have employed for its analysis merely such pieces as are the least mixed with quarz, and, at the same time, the most free from copper-pyrites and galena, which accompany this ore.

<sup>\*</sup> Chemische Annalen, 1793. I. Band. Seite. 10.

<sup>†</sup> Handbuch der Mineralogie, Leipzig, 1794, page 716.

<sup>‡</sup> Lehrbuch der Mineralogie, II. Theil. Giessen, 1796. Seite 203.

#### A

## Examination in the dry way,

- a) If bifinuthic filver-ore, in finall fragments, be ignited upon charcoal before the blow-pipe, there foon transude metallic drops of easy fusion; which eliquate\* more perfectly on the addition of borax. The glass of borax acquires by them a yellow colour, resembling that of amber (Succinum), but mixed with white, and in some places also with a copper-red. The metallic button exhibits variegated colours, and continues long in sussion. It is brittle, and appears of a tin-white in the fracture.
- b) When three hundred grains of this ore, previously triturated, had been exposed to a red-heat, in a small retort, lodged in sand, they afforded,—besides a slight quantity of aqueous moisture, no more than  $2\frac{\pi}{2}$  grains of sulphur; the pure yellow colour of which proved the total absence of arsenic. On the powder of the ore, which coalesced but moderately, some metallic drops were sound incumbent. It was then roasted in an open test, until no trace of sulphureous smell could be observed. After this process, it had an ash-grey colour, appeared of a very loose texture, and weighed 313 grains.

On being combined with  $1\frac{x}{2}$  ounce of black flux, and reduced in an affaying-crucible, under a layer of culinary falt, it ran into a tin white metallic button, which weighed 174 grains, would admit of being cut with a knife, and, though it had become malleable, yet was brittle, and fell afunder after some blows of the hammer.

<sup>\*</sup> On the process of eliquation, in general, see Gren's Principles of Chemistry, Lond. 1800. vol. II. page 301.—Transl.

This metallic bead, when refined by cupellation, under the muffle, afforded a button of pure reguline filver, weighing 33½ grains.

B.

## Examination in the humid way.

- a) Upon three hundred grains of this ore I poured three ounces of nitric acid, diluted with one ounce of water. A great part of it dissolved in this menstruum, even in the cold. The residue was afresh combined with one ounce of the same acid, weakened with half an ounce of water, and digested in a gentle heat. Both solutions, thus obtained, were filtered, mixed, and together evaporated to a smaller volume; during which process there separated from the sluid some crystalline grains, consisting of nitrat of lead.
- When afterwards diluted with just as much of water as was requisite to re-dissolve that crystalline sediment, it was poured into a large quantity of water. This last immediately acquired a milky appearance, in a high degree, and deposited a white precipitate, which weighed 44½ grains, when collected, lixiviated, and dried in the air, and proved, on farther examination, to be oxyd of bismuth.
- c) Into the liquor, that had been freed from this oxyd, and was entirely clear and colourless, I then dropped muriatic acid, as long as it was rendered turbid by it. The precipitate which then ensued, did not appear to be mere muriat of silver; for this reason, I digested it for some time with a moderately strong nitric acid. A considerable portion of it was thus re-dissolved, and lest pure horn-silver behind; which, upon careful collection, and desiccation in a brisk heat, weighed 46 grains. Thus, the portion of pure filver is determined at  $34\frac{\pi}{2}$  grains.

d) The

d) The nitric acid, that had been affused upon the precipitate obtained by the muriatic (c), yielded, by dilution with much water, 32 grains more of oxyded bismuth; which, with the preceding  $44\frac{1}{2}$  (b), gave together  $76\frac{1}{2}$  grains.

In order to ascertain the proportion of reguline bismuth in this ore, I dissolved 100 grains of bismuth in nitric acid; and after having concentrated the solution by evaporation, I poured it into a large quantity of water. When of the precipitate, thus produced, nothing more would fall down, on adding more water, I collected it on the filter, washed it, and suffered it to dry perfectly in the air. It then weighed 88 grains. To the water, which had been separated from it, muriatic acid was added by drops; whereby a new precipitate ensued, weighing 35 grains, after edulcoration and drying.

As, by the refult of this comparative experiment, one bundred grains of reguline bifmuth have, upon the whole, given 123 grains of oxyded bifmuth; it follows, that the  $76\frac{1}{2}$  grains of bifmuthic oxyd, mentioned at (d), and obtained from 300 grains of the bifmuthic filver ore, contain  $62\frac{1}{3}$  grains of metallic, or reguline bifmuth.

- e) The remainder of the fluid was farther reduced by evaporation; and, in this process, muriat of lead separated from it in delicate, broad-striated crystals. This liquor was then combined with such a quantity of sulphuric acid, as was requisite to re-dissolve those crystals, and a second time evaporated to a consistence of pap. The precipitate, which thence ensued, was sulphat of lead, weighing 19 grains, when duly collected, washed, and dried.
- f) What still remained of the solution, after its having been freed from the lead before contained in it, was saturated

rated with caustic ammoniac added in excess. In this way a brown ferruginous precipitate was produced; which was rapidly attracted by the magnet, and weighed 14 grains; when, after previous deficcation, it had been moistened with linfeed-oil, and well ignited.—For these we must reckon 10 grains of metallic iron.

- g) The liquor, which had been fuper-faturated with ammoniac, and which, by its blue colour, fhewed that it held copper in folution, was next faturated to excess with fulphuric acid. On immerfing then a piece of polished iron into it, two grains of copper were deposited.
- b) The grey residue of the ore, that was left behind by the nitric acid (a), weighed 178 grains. But when its sulphureous part had been destagrated, in a crucible gently heated, it weighed only 140½ grains. This determines the portion of sulphur at 37½ grains.
- i) These 140½ grains were digested with three ounces of muriatic acid, in a heat of ebullition; and this process was repeated once more with 1½ ounce of the same acid. These solutions, by means of evaporation, yielded till the end muriat of lead in tender spicular, and likewise in broad-striated crystals; which, when again dissolved in the requisite quantity of boiling water, then combined with sulphuric acid, and evaporated, yielded 89 grains of sulphated lead. Thus the whole quantity of this sulphat, including the 19 grains mentioned at (e), amounted to 108 grains; for which, according to comparative experiments, 76 grains of reguline lead must be put in the computation.
- k) That portion of the ore examined, which still remained after all the constituent parts before mentioned have been

been discovered, confisted merely of the grey quarzose matrix; the weight of which, in the ignited state, amounted to 70 grains.

Therefore, those three hundred grains of bismuthic silverore, mentioned above, were decomposed into:

Bifmuth       d)       62,20         Silver       34,50         Iron       f)       10         Copper       g)       2         Sulphur       h)       37,50         Quarzofe matrix k)       70	Lead .		i)		76
Iron       . f)       . 10         Copper       . g)       . 2         Sulphur       . b)       . 37,50	Bismuth		·d)		62,20
Capper       .       g)       .       2         Sulphur       .       b)       .       37,50	Silver .		6)		34,50
Sulphur . h) 37,50	Iron .	•	f)		10
The state of the s	Copper		g)		2
Quarzose matrixk) 70	Sulphur		b)		37,50
TO THE RESIDENCE OF THE PARTY O	Quarzosen	natri	xk)		70

292,20 grains

It follows from this statement, that, exclusively of the quarzose gangue, the constituent parts of the bismuthic silverore alone consist, in the hundred, of:

Lead .		0	33
Bismuth			27
Silver			15
Iron .			4,30
Copper			 0,90
Sulphur	4.		16,30
			96,50

#### LXVIII.

#### CHEMICAL EXAMINATION

OF THE

## ANTIMONIATED SILVER,

from Wolfach, in Suabia.

ANOTHER fossil, which is found only in the mines worked in the principality of Fürstenberg, is the Antimoniated Silver. It occurs there in the pit, called Wenzelsgrube, near Alt-Wolfach; and its external characters have also been described by Widenmann\* and Emmerling†, in their elementary Introductions to Mineralogy.

It has already been proved by Bergmann 1, but more circumftantially by Selb §, that this mineral is a compound of native filver and reguline antimony.

Selb employed in his experiments that variety of antimoniated filver, which, in former times, has occurred more frequently in coarse-granular detached pieces; and he found its proportion of silver to amount from 70 to 75 in the hundred. But the fine-granular variety, which is now dug, is considerably more rich in silver.

<sup>\*</sup> Handbuch der Mineralogie, 1794, page 684.

<sup>†</sup> Lebrbuch der Mineralogie, II. Theil. page 162.

<sup>†</sup> Opusc. Phys. et Chem. vol. II. page 416.

<sup>§</sup> Magazin für die Bergbaukunde, von Lempe, III. Theil. page 5.
FIRST

#### FIRST SECTION.

Antimoniated Silver in fine Grains.

#### A.

## Examination in the dry Way.

- a) A small piece of antimoniated filver, when tried upon charcoal, with the affishance of the blow-pipe, soon entered into suspenses. The antimonial part volatilized in its usual vaporous state, and lest the button of silver entirely pure behind. Neither of sulphur nor of arsenic any trace appeared.
- b) Twenty-five grains, mixed with four times their weight of lead, and subjected to cupellation, yielded a button of pure filver, weighing 21 grains.

#### B

## Examination in the humid way.

a) Nitric acid was poured upon hundred grains of antimoniated filver, freed from calcareous fpar adhering to it, and pulverized as much as its toughness would admit. The acid shewed no considerable action in the cold. Therefore I subjected the whole to a digesting heat, in which I kept it, until nitric acid, added afresh, would not farther attack this powder. Upon this I diluted the mixture with water, separated the residue, and precipitated the silver from the colourless solution, by means of copper. The silver, thus obtained, amounted to  $83\frac{1}{2}$  grains, when lixiviated and dried in a warm temperature.

- b) The refidue exhibited a reddiff-white colour, after being washed and deficcated in the air, and weighed 25 grains. It soon dissolved in the muriatic acid, with which it was digested; leaving behind it a small portion of muriated silver, which, upon reduction, by means of soda, in the small spoon, still gave ½ grain of silver.
- c) I poured the muriatic folution into a large quantity of water. By this management it was decomposed, and let fall a white, tender precipitate; which, dried in a gentle heat, weighed 20½ grains. This precipitate, upon trial, proved to be an oxyd of antimony, perfectly resembling powder of algaroth (oxyd of antimony by the muriatic acid). One part of it I re-dissolved in muriatic acid; and the solution, when poured into water previously impregnated with sulphuret of ammoniac, yielded golden sulphur of antimony, of a pure orange colour. The remaining part gave, by reduction with tartar, a metallic button; which, on being blown off with the bellows, entirely evaporated, without leaving any residue.

Therefore, fince, by the refult of other comparative experiments \*, 16 grains of reguline antimony may be reckoned for those  $20\frac{1}{2}$  grains of the metallic oxyd (c), the constituent parts of the fine-granular variety of the antimoniated filver are in the following proportion:

Silver			84 16
		-	100

<sup>\*</sup> See page 130 of this work.

of the antimoniated Silver from Wolfach. 563

## SECOND SECTION.

Antimoniated Silver in coarse Grains.

ONE hundred grains of the coarse-granular variety of antimoniated silver, when decomposed in the same manner as the preceding, yielded:

Silver .			10 -		76
Reguline	antimon	y .	April .		24
				-	
					100

# XIX

#### CHEMICAL EXAMINATION

an radianm smal ods at Lior THE

## CRYSTALLIZED, BRIGHT, WHITE

COBALT-ORE,

(Glanzkobalt),

From Tunaberg, in Sweden.

THE crystals of the Bright, White Cobalt-ore, which occurs at Tunaberg, in Südermannland, together with the copper-pyrites (yellow copper-ore), are distinguished by the stronger metallic lustre of their external surfaces, which renders them less liable to decay, as well as by their size, of a rather uncommon magnitude \*.

The colour of their furface and recent fracture is a tinwhite paffing into the grey; and the form of their crystals consists, for the most part, in variations of the cube, with unequally truncated edges, and striated lateral facets. The striæ, or small channels of each surface, are parallel to those of the opposite one, but perpendicular to those of the ad-

<sup>\*</sup> One of these crystals, extremely beautiful and large, and detached from others, is in the possession of M. Mierotto, Counsellor in the Ecclesiastical Department at Berlin; whose collection of minerals is so highly instructive with regard to the Geognosy of the countries situated on the Baltic sea. This crystal is 1½ inch long, of the same height, one inch broad, and weighs 4½ ounces.

joining fide. This remarkable direction of the firia has, till now, been found only in this cobaltic ore, and in some cubes of fulphur-pyrites, ftriated in the fame manner. fracture of these crystals is uneven, and exhibits a foliated texture. by any other aqueous foluni

## I. Experiments in the humid way.

finic (orgineat), and the gight pightent of School with am-

One hundred grains of this cobalt-ore were digested with nitro-muriatic acid, in a boiling heat. The metal dissolved but flowly, and in a small quantity. As long as the solution was hot, it appeared of a dark emerald-green; but, upon cooling, it turned reddish-brown. No arsenic would depofite from it. Hence, the above menstruum did not seem likely to effect the decomposition which I intended of the cobaltic ore.

#### R

- a) Hundred grains of rough white cobalt-ore, when gently digested with nitric acid, dissolved in it gradually; however, leaving behind them 161 grains of small, whitegrey, resplendent globules, which consisted of arsenic, together with a little fulphur. By boiling with water, this arfenical ingredient was diffolved, and there remained 11 grain behind; of which i grain of fulphur deflagrated on a small hot test. The remaining I grain was oxyd of cobalt.
- b) The brownish-red nitric solution was evaporated to a part, on a fand bath. In this process there still separated an oxyd of arsenic, in the form of a white crystalline incrustation; which, collected after cooling, and by degrees lixiviated with a little water, weighed 30 grains after deficca-

003

tion. It again entirely diffolved in the water with which it was boiled.

- c) Both the folutions of the arfenical oxyd in water flewed exactly the same appearances which are exhibited by any other aqueous solution of arsenic. By combination with lime-water, they yielded arseniat of lime; with sulphuret of ammoniac they produced yellow sulphuret of arsenic (orpiment), and the green pigment of Scheele with ammoniacal oxyd of copper.
- d) When the nitric folution of cobalt would no longer deposite any arsenic, I diluted it with water, and precipitated, by means of vegetable alkali, the oxyded cobalt; which, at first, had a peach-slower colour, and, towards the end, that of lilac. On dissolving this last, precipitated in muriatic acid, and diluting the solution with water, the liquor acquired a rose-red colour, and afforded the well-known sympathetic ink prepared from cobalt.

Therefore, the conflituent parts of the *crystallized*, white cobalt-ore, separately produced in this analysis, consist, in the hundred, besides the portion of cobalt itself, of 45 grains of arsenical oxyd, and  $\frac{1}{2}$  grain of sulphur: but of any portion of iron no trace appeared.

However, as I had reason to suppose that the ingredient proportion of arsenic here stated might, perhaps, not be the true one, I endeavoured to ascertain it more accurately in the dry way.

## II. Experiments in the dry Way.

#### A.

a) Four hundred grains of white cobalt-ore, coarfely powdered, were heated to redness in a small glass retort, connected nected with a receiver, and kept in the state of ignition for fome time. After cooling there appeared in the neck of the retort no more than one grain of sublimed arsenic, together with a slight trace of sulphur.

- b) The contents of the retort were then introduced into a small open matrass, and once more strongly ignited; but no sublimation ensued.
- c) Upon this, I mixed the cobalt with 1-4th part of its weight of powdered charcoal, and calcined it in a shallow open pot. At this instant the arsenic escaped in vapours; but slowly, and it coated metallic substances, that were held over the pot, with a thick white crust. The smell of this vapour resembled that of garlic, only in very moderate degree; and it ceased to be emitted after the roasting had been continued for two hours.

But, by this calcination, the cobalt was not yet entirely deprived of all portion of arfenic; for, when it had been diffolved in nitric acid, and the folution concentrated by evaporation, there was still some arsenic deposited.

#### B.

a) For this reason, another two hundred grains of rough, white, cobalt-ore, previously triturated, were, in the first instance, mixed with 100 grains of charcoal-dust, and calcined. This roasting was twice repeated, mixing the ore each time with 50 grains of powdered charcoal; after which it no longer emitted any trace of exhaling arsenic. The cobaltic oxyd, which now, to appearance, had been entirely freed from arsenic, weighed 104 grains, and exhibited a black colour.

- b) These 104 grains were mingled with carbonat of potash and crude tartar, of each three drachms. The mixture, when introduced into a small crucible, and covered with muriat of soda, was kept in the fire, before the nozzle of the bellows, during 20 minutes. The cobalt, thus reduced to the reguline state, was found to weigh 75 grains. Its external surface had a finely knit, or interwoven appearance. But when I endeavoured to break it by the hammer, it proved to be hard, and somewhat tenacious. Its internal surface was partly porous; partly it exhibited a rough fracture, passing into the backly, that is, presenting sharp points to the feel.
- c) After these 75 grains of metallic cobalt had been pounded, they were roasted, in a brisk fire, for two hours; upon which the calcined cobalt appeared again in the character of a black oxyd, with an increase of weight of 18 per cent.

Since it may be prefumed, with probability, that this cobaltic oxyd, which has been re-produced from the reguline cobalt revived at (b), contains oxygen in the fame proportion with the oxyd prepared by roasting the rough cobalt ore; and, as consequently, those 104 grains (a) of oxyded cobalt have contained 88 grains of pure reguline cobalt; it follows, that the constituent parts of this white cobalt-ore, from Tunaberg, are, in the hundred:

Reguline	cobalt		DE.		44
Sulphur		1.			0,50
Reguline	arsenic	1		3,0	55,50

100

#### LXX.

#### CHEMICAL EXAMINATION

OF THE

## COBALTIC ORE OF MANGANESE,

From RENGERSDORF, in Lusatia.

THE fossil that was the object of the present enquiry occurs near Rengersdorf, in Upper-Lusatia, in a stratum of quarz, which, on the Heideberg, comes up to the day. It has, till now, been considered as a black hæmatitic iron-stone, until the late Professor Leske has introduced it as a black cobaltore. However, as he declared to entertain a wish that this classification, which he founded partly on the external characters of this fossil, partly on some previous experiments made with it \(\frac{1}{2}\), might be farther examined by a chemical analysis, it was by this declaration that M. Westrumb was induced to undertake this task.

From the appearances which this celebrated chemist obferved on experimenting with this fossil, it resulted, that it contained manganese: but, on the other hand, he denied it to contain a portion of cobalt §, which, however, Leske had suspected in it.

<sup>\*</sup> Schwarzer, Glasköpfiger Eisenstein.

<sup>+</sup> Schwarzer Erdkobalt.

<sup>†</sup> Reise durch Saxen von N. G. Leske. Leipzig, 1785, Page

<sup>§</sup> Kleine Phys. Chem. Abhandlungen, von Westrumb, 2ter Band, 2 Heft, 1788, page 183.

My examination of this mineral substance, of which I have received a stock from M. de Gersdorf, the worthy proprietor of the estates of Messersdorf and Rengersdorf, where it is found, has convinced me that, besides manganese, it indeed contains cobalt: but it has, at the same time, shewn, that the presence of cobalt is hid by the predominant portion of manganese combined with it, or, at least, rendered unobservable on the first inspection of the sossil.

#### A.

- a) The rough fossil, when treated upon charcoal, under a stream of air, continued for some time from the blow-pipe, sufes into an apake, blueish scoria.
- b) Phosphoric salt produces with it, by the same treatment, a crimson-red vitreous globule.
- c) Borat of foda is tinged by it of a dark hyacinthinered; which colour, on adding a flight portion of arfeniated foda, paffes into a pale blue.
- d) One hundred grains of this fossil were first calcined in a gentle heat, and afterwards ignited during half an hour. The fossil lost thereby 17 grains in weight, and its blackish colour was changed to a dark ash-grey. During this process of roasting, there could not be observed either smoke or smell; and the loss consisted merely of aqueous particles.

#### B.

a) Five hundred grains of this fossil, previously comminuted in the mortar, were digested with a moderately strong mu-

muriatic acid. There escaped vapours of oxygenated muriatic acid. By continuing the digestion at the degree of ebullition, the mixture lost its brown colour, and the sluid became green, leaving a white earthy residue behind. But, on diluting the solution with water, its green colour disappeared, and the filtered liquor acquired a weak brownish-red. The residue, separated by filtration, weighed 206 grains, after ignition.

- b) I then reduced the volume of the muriatic folution by evaporating it; during which process filiceous earth was deposited, weighing 10 grains, when collected on the filter and ignited. After this I saturated the solution with dissolved caustic pot-ash, added in excess, kept the mixture for some time in digestion, and filtered it. A muddy residue remained on the paper, the dirty light-brown colour of which rapidly turned black on exposure to air.
- c) The fluid separated from this residue was neutralized with muriatic acid, and then combined with carbonat of pot-ash. It deposited aluminous earth, the quantity of which, after ignition, amounted to 12 grains.
- d) The above black residue (b) was again dissolved in muriatic acid, and thrown down by mild vegetable alkali. The precipitate appeared of a pale-reddish colour. When edulcorated and dried, I subjected it to strong red-heat, for one hour, in a calcining pot. It returned from the fire of a greyish-brown hue, and weighed 178 grains.
- e) I subjected these 178 grains, for some time, to digestion, in a boiling heat, with a moderately strong nitric acid, diluting afterwards the solution with water, and filtering it. There remained a tender, black residue behind, which, upon edulcoration, drying, and ignition, weighed 80 grains,

grains, and was oxyd of manganese. In order to try it for iron, I again digested it with nitric acid; in which, on the addition of a little sugar, it immediately dissolved, without leaving iron, or any other residue. When again precipitated by means of carbonated pot-ash, it fell down as a carbonated oxyd of manganese, of a white colour, verging into the isabella yellow.

- f) Hence the nitric folution still contained 98 grains of the mentioned 178; but from the first there must be subtracted one grain for copper, discovered in the sequel. By mild vegetable alkali, this re-dissolved portion was again precipitated, of a pale colour of peach-slower; and this precipitate, as the following examinations of it have shewn, consisted of an accurate mixture of oxyds of cobalt and manganese.
- g) The 206 grains, which remained on diffolving the crude fosfil (a), were mixed with twice their weight of carbonated pot-ash, and moderately ignited during two hours; after which they were covered with water, super-saturated with muriatic acid, and evaporated to a gelatinous consistence: and when the filiceous earth had been separated, washed, and ignited, it was found to weigh 114 grains.
- b) I then neutralized the remaining muriatic liquor with carbonat of pot-ash, and combined it afterwards with oxalat of pot-ash: but by this neither any precipitation nor turbidness has been effected. It was then combined with caustic ammoniac, which threw down aluminous earth, the quantity of which, after ignition, consisted of 90 grains. The still remaining portion of the sluid continued clear on the addition of carbonated soda.
- i) With a defign to ascertain the proportion of copper which enters into this fossil, and the presence of which has

already been observed in the previous experiments, I affused sulphuric acid upon 500 grains of the rough soffil, evaporated the fluid on a sand-bath, softened the inspissated mass with water, and immersed, after filtration, a polished plate of iron into the clear solution, which had acquired a pale rose colour. The plate of iron became gradually incrustated with a cupreous pellicle; which, when carefully collected, weighed no more than  $\frac{1}{2}$  grain; and thus one grain of oxyd of copper must be put in the computation.

Therefore, the five hundred grains of the fossil here examined have been decomposed into:

Oxyd of cobalt, mixed with	A miles y
oxyd of magnesia B. f)	. 97
Mere oxyd of manganese e)	. 80
Oxyd of copper i)	1
Silan h ro	124
( g) 114 §	124
Alumine	****
— b) 90\$	102
Water A. d)	85
endiminations have obtaining at boulding at a	O -
time air lo etc. ou in second d'encore d'une les	489

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But, that the 97 grains mentioned at (B. f), and which were obtained in the carbonated state, have really consisted of a mixture of oxyded cobalt and manganese, has been proved by the following experiments; the phenomena of which, at the same time, were compared with those that are exhibited by the pure carbonated oxyd of manganese.

t. a) The colour of the above precipitate, in the carbonated state, is the pale peach-slower red, and changes, on ignition, into the light-brown.

## 574 LXX. Examination of the Cobaltic

- b) The colour of the carbonated manganesian oxyd is white, inclining to the isabella-yellow; and that of ignited oxyd of manganese is black-brown.
- 2. a) If the ignited cobalto-manganesian precipitate be digested with nitric acid, in a boiling heat, it leaves behind it a residue in the form of a subtle, black powder. If then carbonated pot-ash be added to the filtered solution, which has a very pure, but dilute rose-red colour, the dissolved matter is thrown down by the alkali, of its former peach-slower red. The black residue, left unattacked by the nitric acid, when heated to redness, and digested in a heat of ebullition with a fresh portion of nitric acid, is redissolved for the greatest part; and its dissolved portion is again precipitated, of a pale red colour, by mild pot-ash.
- b) The ignited black-brown oxyd of manganese, by itfelf alone, is insoluble in nitric acid; the acid that is boiled with it continues colourless, and lets nothing fall down on being saturated with an alkali.
- 3. a) If the above compound precipitate of cobalt and manganese be dissolved in muriatic acid, and abundantly superfaturated with carbonated ammoniac, the clear sluid which stands over the sediment acquires, after some time, a dilute colour, resembling that of the blossom of slax-weed.
- b) The oxyd of manganese, on the contrary, when disfolved in the same manner in muriatic acid, and precipitated by carbonat of ammoniac, added to excess of saturation, leaves the liquor standing over the sediment entirely colourless.
- 4. a) On adding the mentioned cobaltic precipitate of manganese to a neutral phosphat, sufed upon charcoal, the clear globule becomes tinged of a pure sapphire-blue colour, which

which continues unchanged by the outer, as well as by the inner flame of a candle, directed on it by the blow-pipe.

- b) Oxyd of manganese, alone, produces with the phosphoric salt a globule, which is devoid of all colour when urged by the interior slame, but acquires an amethystine red by the heat of the exterior.
- 5. a.) The combination of borax with the cobalto-manganefian precipitate, upon the charcoal, before the blow-pipe, produces a glass globule of a dirty blueish colour, inclining to the blackish-grey. But as soon as a small quantity of arseniated soda is added, a pure sapphire-blue colour appears.
- b) Oxyd of manganese imparts to borax, when vitrifying upon the coal, a dark amethystine, and sometimes a hyacinthine red colour. But the glass globule is immediately rendered colourless by the addition of arseniat of soda.
- 6. a) When the precipitate compounded of cobalt and manganese is dissolved in concentrated muriatic acid, the solution acquires a pale rose colour, and it becomes grassgreen by heating. As the solution cools, its green colour disappears, and the pale-red returns. If this solution be diluted with water, and employed instead of ink, the characters written with it become visible, of a green colour, on warming the paper gently; but, upon cooling, that colour disappears, and returns again when warmed; and so on, alternately. However, if the paper be heated too strongly, the traces made on it acquire a brown and permanent colour.
  - b) The folution of oxyd of manganese alone, in concentrated muriatic acid, is, for the most part, entirely colour-

5

lefs: neither does it acquire any tinge by warming it. The traces written on paper with this folution, previously diluted with water, continue invisible if the paper be exposed to a gentle heat only: but by a stronger heat they turn brown, and lose no more that colour, even after cooling.

#### D.

All these phenomena sufficiently evince the presence of cobalt in the above compound reddish precipitate. However, fince the colours exhibited by this precipitate are, in all their changes, paler than those which are produced by the oxyd of cobalt prepared from genuine cobalt-ores, it appears that the cobaltic is its smaller part. The manganese, on the contrary, constitutes the greater portion: and it seems that in this precipitate there obtains an intimate union between these two metals: for, although a great part of the manganese may be made separable by strong ignition, by which it is rendered insoluble in nitric acid; yet I could not succeed in separating entirely the remaining part of manganese from the ingredient cobalt, by repeated ignition and boiling in nitric acid.

It is on account of the manganele, so intimately combined with the cobalt, that neither the crude sossil, nor the reddish precipitate separated from it, imparts a true blue colour to vitrifying substances.

Yet, notwithstanding this, the mentioned arfenical addition (5. b) affords a practicable means of rendering the ingredient portion of manganese ineffectual in tinging glasses. The reason of this is, that the manganese combines, and enters into a state of complete saturation with the oxygen, which it seizes from the admixed arseniat of soda. And as, in this situation, it does not, of its own accord, tinge vitrifying

fying fubstances, it likewise no longer prevents the cobalt from imparting a pure sapphire-blue colour; as is confirmed by the following experiments.

1, To five parts of that peach-flower coloured precipitate, previously dissolved in muriatic acid, I added a solution of two parts of arseniated soda, and effected a precipitation by means of carbonated soda. The precipitate, in this instance, acquired a lavender-blue, instead of a reddish colour; and, when added to a globule of borax, melted upon charcoal, it immediately coloured it of a pure sapphire-blue.

2.	a) Silex	I
	Calcined borax	½ ounce of each.
	Reddish cobalto-manganesian	to photos in the last.
,	precipitate	10 grains,

mixed and vitrified in a porcelain-pot, afforded a glass of a weak and cloudy amethyst-colour.

yielded a glass of a very pure sapphire-blue colour, though not of that intensity which an equal quantity of oxyded cobalt, prepared from the common good cobalt-ores, imparts to similar glass-frits.

produced a smalt-blue glass, the violet colour of which too much inclined to a dirty brown-red.

PP

## 578 Examination of the Cobaltic Ore, &c.

6)	Silex		,.	4	7.	
	Carbonated pot-ash				3 = 0	ounce of each,
	Rough fossil				2	was self transfer
	Arseniat of soda .					drachms,

gave a smalt-blue glass, of a pure violet colour.

4. It yet remained to examine what colour would be produced by the cobaltic portion of this compound metallic oxyd, in the encaustic painting on porcelain. For this purpose, a part of the lavender-blue arsenical precipitate, prepared as before (No. 1.) was conveyed upon porcelain-vessels, previously ignited, and then sufed upon them. The painting returned from the surnace in every respect of a pure cobalt-colour, though rather weak.

Befides these experiments, I performed a number of others with several variations, with a design of ascertaining the proportion of cobalt in the ore here examined, as well as of separating its oxyd of cobalt in a state entirely free from all admixture of manganese. But, since the result would not answer my wishes, I abstain from giving here an account of those experiments; and am, at present, satisfied with having demonstrated the presence of cobalt in this black, earthy ore of manganese from Rengersdorf.

#### LXXI.

## CHEMICAL EXAMINATION

OF THE

#### NATIVE SULPHAT OF COBALT.

(Kobaltvitriol)

From HERRENGRUND, in Hungary.

AT Herrrengrund, near Neufohl in Hungary, a vitrolic falt occurs, in pale rose-red, transparent crystals, of a stalattical form; which is considered by some as a sulphat of manganese, but by others as a sulphat of cobalt.

To remove this doubt, I undertook the following examination of this fossil; and the result decided for the latter opinion.

Hundred grains of this metallic falt, when diffolved in water, and precipitated by carbonat of pot-ash, afforded seven grains of a loose, pale-blueish precipitate, which turned black on exposure to a red-heat. This precipitate, when suffed upon charcoal, imparted to the glass-globule produced by the vitrification of a phosphoric neutral salt, as well as to that which is obtained in the same manner from borax, a pure sappharine blue colour. Its remaining part, that had not been employed for these experiments, yielded, upon solution in dilute muriatic acid, a sympathetic ink; the traces of which directly assumed a yellowish-green colour on warming the paper, but disappeared again as the paper cooled.

LXXII.

#### LXXII.

#### CHEMICAL EXAMINATION

OF THE

## MINERAL SPRINGS AT IMNAU\*,

In SUABIA.

AMONG the many various mineral waters with which beneficent Nature has provided several parts of Germany, there are some which, by accident and good fortune, have acquired same and credit; while others, on the contrary, though not less valuable, have either continued to be totally unknown, or have undeservedly sallen into neglect and oblivion.

To these latter belong the mineral-springs at Imnau, a borough in Suabia, situated between Tübingen and Roth-weil, in the estate Haigerloch, which is the property of Prince Hohenzollern-Sigmaringen.

Although these springs had been famous as early as the times of Taberna-montanus, I have not yet seen of them any account earlier than that given by Caspar +. But how little satisfactory his information can be with regard to the

<sup>\*</sup> Chemische Annalen, I. Band. page 1792,. 333.

<sup>†</sup> Beschreibung des Saeurbrunnens zu Imnau, &c. durch Sam. Caspar. Med. Dr. und Physicus zu Sulz am Neckar. Ulm. 1733, 8vo.

nature and conflituent parts of the water, may be concluded even from the date of its publication; as, in general, at that time a well-founded chemical analysis of water could not even be thought of.

By the care of Dr. Mezler, physician to the Court of Hohenzollern-Sigmaringen, I obtained, of the mineral-water at Imnau, a quantity sufficient for examination, in five well-stopped, and numbered bottles; the waters of which were taken from as many contiguous springs, flowing into one common reservoir.

When the water arrived at Berlin it was found bright and clear; it frothed strongly on being poured into glasses, and had an agreeable and strong taste of carbonic acid. From this description only the water from the springs 4 and 5 ought to be excepted; because, with respect to smell, as well as taste, it seemed to be impregnated with sulphurated hydrogen-gas.

Each of the waters contained in those bottles I have first previously tried by means of re-agents. They were then subjected to analytical examination, in order to produce their constituent parts in a separate state.

#### A.

## Examination by means of Re-agents.

## 1. Tincture of Litmus.

- a) The crude water of all the five bottles, acquired by the tincture of litmus, a fine red colour.
- b) When it had been reduced to one half by boiling, and filtered, it continued blue, on the addition of that time-ture.

II.

- II. Paper tinged with a decoction of Brafil-wood.
- a) The colour of the crude water changed the red colour of the paper to a violet.
- b) Boiled water produced no change in the colour of that paper.

#### III. Lime-water.

On mixing equal parts of lime-water, and the water from each bottle feparately, the mixture was rendered cloudy and of a milk-white; but it rapidly became again clear.—However, by the addition of more lime-water, a quantity of carbonated lime fell down.

#### IV. Concentrated Mineral Acids

disengaged from the water of each bottle numerous air-

V. Carbonat of Ammoniac, and Carbonat of Soda, produced a precipitate, which was thrown down entirely white, from the waters of the 1, 2, and 3 bottles; but that of the 4 and 5 bottles had an ash-grey colour.

VI. Cauftic Ammoniac, and cauftic Soda, yielded the same precipitates as at V. but in a less quantity.

VII. Spirituous Tincture of Nut-galls.

The water of the bottle, No. 1, suffered no change from it, except that it acquired a weak yellowish shade. But in the waters of the bottles marked 2, 3, 4, and 5, a purple

ple precipitate was thrown down by this tincture, and the fupernatant liquor acquired a violet colour, inclining to the green.

#### VIII. Oxalic Acid

immediately effected a copious precipitation.

## IX. Muriat of Barytes

produced a precipitate in but a moderate quantity.

## X. Sulphat of Magnefia

- a) Threw down from the rough water, after 24 hours, a precipitate sufficient to be observable.
- b) But the boiled water, combined with the fame falt, was not rendered turbid, and it continued clear.

## XI. Nitrat of Silver.

The water of bottle i continued at first unaltered, but afterwards it became a little opalescent. Those of the bottles No. 2 and 3 were altered very little; they, however, acquired a brownish tinge. The waters of bottles 4 and 5 were immediately rendered blackish, and deposited a black sediment.

## XII. Acetate of Lead.

In the waters of the bottles 1, 2, and 3, it produced a white, and in those of the bottles 4 and 5 a dirty, light-brown sediment.

## XIII. Running Mercury,

preserved in the waters of the bottles 1, 2, and 3, its bright lustre; but it became tarnished of a blackish hue, when immersed into the waters taken from the 4th and 5th bottles.

## XIV. Leaf of beaten Silver.

Small pieces of this continued unchanged in the waters of the 1, 2, and 3 bottles; but in those of the 4th and 5th they became tarnished, first of a gold, and then of a coppercolour.

B.

## Analytical Examination.

As a detailed explanation of every feparate experiment would occasion unnecessary repetitions; to avoid these, I shall relate only, in a few words, the method which I pursued in these researches. To this I shall add, in a summary way, the constituent parts which I have discovered in the water of each particular spring, together with their proportion to each other.

## I. Examination of the gaseous constituent part.

It has already refulted from the preceding refearches, that this mineral water is richly impregnated with carbonic acid gas. To afcertain the quantity of this gas, its extrication and collection were performed by means of the mercurial pneumatic apparatus.

On examining the waters taken from the bottles No. 4 and 5, the mercury in the cylinder became incrustrated, at

its upper furface with a brown pellicle, during the operation; but this did not take place with the waters of No. 1, 2, and 3.

The gas, that was difengaged from the water of each bottle, was totally absorbed by lime-water, and produced carbonat of lime. But in the common air, that occupied the space left in the retort after the introduction of the mineral water, and which was driven over along with the carbonic acid gas, I could not discover any extraneous matter.

## II. Examination of the fixed constituent parts.

a) One hundred cubic inches of water (reckoning the weight of water, filling the capacity of one cubic inch, equal to 290 grains of distilled water), from each spring separately, were evaporated at a moderate temperature in a glass-dish. The water

of the bottle No. 1, left 313 grains

 $36\frac{1}{4}$ 

of a dry refidue. That of No. 1 had a white, those of No. 2 and 3 a light reddish-grey, and those of No. 4 and 5 a reddish colour, of a little deeper cast.

b) All these residues were first treated with alkohol, during 24 hours. The ardent spirit became imbued with a faint yellowish colour, and when separated by siltration, and evaporated, it lest behind it so slight a portion of a brown mass, that its farther decomposition was not well practicable. For this reason I collected it, by means of alkohol, into one mass, from all the sive evaporating-dishes, and after having suffered the spirit again to exhale, I obtained

a residue weighing sour grains. When this residue had been re-dissolved in very little alkohol, there remained  $1\frac{1}{2}$  grain of muriated soda: and on combining the spirituous solution with sulphuric acid,  $1\frac{1}{2}$  grain of resinous matter was separated. But the sulphuric solution yielded sulphat of magnesia; for which one grain of muriated magnesia may be put in the computation.

- c) After this extraction of the several residues, by means of ardent spirit, I affused water upon each of them separately, and agitated the mixture several times. After 24 hours the aqueous extracts were, by means of the filter, separated from the undissolved portion, and made to crystallize: first, with the assistance of a gentle heat, and then by spontaneous exhalation in the open air. Every one shot into prismatic crystals, which consisted merely of sulphated magnesia; with the exception of that which had been obtained from No. 1, and which alone was accompanied with a nearly unobservable trace of selenite, or gypsum. These saline lixivia left at last a brown moisture behind, which hardly amounted to a few drops, and contained so small a quantity of gumnous-extractive matter, that it could not be estimated.
- d) Upon the portion that remained undiffolved in water, I poured alkohol, and afterwards I dropped nitro-muriatic acid into it, until all effervescence and action of the acid ceased. On this process a small quantity of a muddy residue remained behind; which, when collected upon the filter, and ignited, left siliceous earth behind it.

All these solutions, previously filtered, were saturated with caustic ammoniae. By this combination, an hardly observable turbidness was produced in the solution of the residue lest from the water of the bottle No. 1. But in those of the other four residues a ferruginous precipitate ensued; which

which was carefully collected upon the filter, then washed, dried, ignited, and weighed. This I dissolved again in nitro-muriatic acid, in order to separate a small portion of filiceous earth; which still has been mixed with it, and was afterwards collected, ignited, and weighed, for the purpose of ascertaining the true weight of the iron, which the preceding precipitate had contained, by subtracting the weight of the silex from the whole weight of the former. After which, this portion of iron was reduced, in the computation, to a corresponding quantity of carbonated oxyd of iron.

- e) After having thus separated the ferruginous part, I reduced the solutions, in some degree, by evaporation; I combined them with a sourth part of their volume of alkohol, adding, then, concentrated sulphuric acid by drops, which immediately threw down a quantity of selenite. I continued dropping in the acid, as long as any of this sulphat of lime would fall down. The selenite was collected on the filter, and when it had been edulcorated with a mixture of water and alkohol, I again decomposed it, by boiling with an aqueous solution of carbonated soda. The carbonat of lime, thus separated, was washed, dried, and weighed.
- f) To discover whether the fluid remaining from the separated gypsum contained any magnesia, I evaporated it to some part, and combined it with carbonat of soda, at the degree of boiling heat. However, no precipitation took place.

According to the refults of these inquiries, one hundred cubic inches of the waters of the mineral springs at Imnau contain:

## I. Water from the Bottle No. 1.

Sulphat of magnefia, with a trace of felenite.	5,75 grains
Muriat of soda	0,30
Muriat of magnesia	0,20
Carbonat of lime	25
Silex	I
Resinous matter	0,30
Carbonic acid gas, 104 cubic in	32,55 grains aches.

## II. Water from the Bottle No. 2.

The same of the sa				
Sulphat of magnesia .		. 0	5	grains
Muriat of soda			0,30	andre in
Muriat of magnefia .	01		0,20	
Carbonat of lime			27,75	
Carbonated oxyd of iron			0,75	
Silex			I	
Resinous matter			0,30	
		-	25 20	oraine
	*		35,30	grains

## Carbonic acid gas, 105 cubic inches.

## III. Water from the Bottle No. 3.

Sulphat of magnesia .			5,50 grains
Muriat of soda	ø	1.	0,30
Muriat of magnesia .			0,20
Carbonat of lime .			28,25
Carbonated oxyd of iron			1
Silex			I
Resinous matter			0,30
		, .	36,55 grains

Carbonic acid gas, 104 cubic inches.

## IV. Water from the Bottle No. 4.

Sulphat of magnesia	6 grains
Muriat of Soda	0,30
Muriat of magnesia	0,20
Carbonat of lime	31
Carbonated oxyd of iron	1,50
Silex	1
Resinous matter	0,30
Silex	I

40,30 grains

Carbonic acid gas, 112 cubic inches.

## V. Water from the Bottle No. 5.

Sulphat of magnesia	•	5,75 grains
Muriat of soda		0,30
Muriat of magnesia		0,20
Carbonat of lime		29,75
Carbonated oxyd of iron		1,50
Silex		1
Resinous matter		0,30
		-
w Control of the Cont		28 80 mrains

38,80 grains

Carbonic acid gas, 115 cubic inches.

It will be observed, that the sum of the separate constituent parts, in each of the above five computations, is a little greater than the weight of the entire dry residue, that has been at first obtained (B. No. 2. a.). This is to be accounted for by the water of crystallization, which enters into the sulphat of magnesia.

C

In this fummary statement will be found wanting the fulphurated hydrogen gas, suspected before in the waters of the 4th and 5th bottle, or spring (page 581); the presence of which, however, seemed to be indicated by their taste and smell, as well as by the dark colour of the precipitate thrown down by acetated lead, and by the tarnishing of the reguline mercury and silver-leaf (A. No. 13 and 14), immersed into them.

However, fince I have experienced in other inflances, that, in mineral waters, these and fimilar indications originate but rarely from real sulphurated hydrogen gas, and that more frequently they arise from the admixture of putrefying organic matters; I entertained a doubt: whether that putrid vapour be an effential ingredient in the waters of the fprings No. 4 and 5? Of this doubt I informed Dr. Mezler, requesting him to examine this object on the spot. And it resulted from the researches, which he made, that this fmell, refembling that of fulphurated hydrogon gas, was owing merely to the putrescent state of a cement, which had been employed in the conftruction of some pipes, through which it was found necessary to force the water of the fourth and fifth springs into their appropriate refervoirs. This cause has been since removed; hence these fprings are, at prefent, entirely free from all extraneous contamination. When the whole of the water had been pumped out of the refervoirs, and, confequently, when Dr. Mezler was enabled to examine water, that had recently issued from these springs, he found, neither by the taste nor by the fmell, the least trace of that hepatic odour. Befides this, he filled, under the furface of the water, four bottles; the first of which contained some clear pieces of white arfenic; arfenic; the fecond, fome crystals of purified acetate of lead; the third, beaten leaf-silver; and the fourth, running mercury: stopping all these bottles closely. After 24 hours, the arsenic was found as white as before; the precipitate produced by the acetated lead was of a beautiful white; and the metallic lustre of the silver and mercury was not in the least impaired.

END.

#### ERRATA.

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479 . 12 — fulphuric . . . . fulphureous.
500 . 24 — muriatic . . . . fulphuric.
 219 transfer note (*) to page 218.
400 transfer note to — 399.
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Some other typographical errors, and mistakes of less importance, are recommended to the Reader's kind indulgence.

